MONTANA WIND ENERGY ATLAS

1987 EDITION

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MONTANA
WIND ENERGY ATLAS

1987 Edition

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Prepared by
GeoResearch, Inc.
Billings, MT

Energy Division
DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
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Abstract

The *Montana Wind Energy Atlas,* developed by GeoResearch, Inc., under contract with the Montana Department of Natural Resources and Conservation, is a comprehensive analysis of wind energy data, designed for use by individuals and organizations interested in wind energy development in the state. Data collected by a variety of public and private organizations at 158 wind monitoring sites around Montana were reviewed. Data from 56 sites are anlayzed in the *Atlas.* Information on the sites and the data collection programs is included.

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Acknowledgments

The original report was prepared by the staff of GeoResearch, Inc., Billings, directed by Michael Machler, under contract to the Department of Natural Resources and Conservation as part of the Sustainable Energy Assessment (SEA) Project. Paul Cartwright was project manager, and with Bill Phippen, edited the report. Dan Nelson did the layout; Rose-Ann Montgomery and Margie Peterson handled word processing. The update was prepared by Paul Cartwright, with additional data analysis by GeoResearch, Inc.

INTRODUCTION

The *Montana Wind Energy Atlas* is a comprehensive analysis of wind energy data designed for use by individuals and organizations involved in wind energy development. It contains wind data that are representative of selected geographical areas across the state. This atlas represents the first time that Montana wind energy data held by numerous public and private entities have been collected, evaluated, and made available in a single volume. The *Atlas* should be a valuable reference for developers and engineers concerned with siting and construction of commercial-scale wind farms, as well as for individuals interested in smaller-scale installations.

The Department of Natural Resources and Conservation contracted with GeoResearch, Inc., of Billings to develop the *Atlas*. The first phase of its development involved a thorough survey of public and private agencies to determine the amount of Montana wind data available. Through this survey, GeoResearch established an extensive meteorological data base for the state; this base included wind speed, wind direction, and atmospheric stability data in hard copy or machine-readable form. The sets within the data base then were evaluated on the basis of length of record, similarity of data collection methods, adequacy of the data, and area for which the data are representative. With the aid of detailed computer programs, the usable data were subsequently analyzed and reduced to summary form for publication. This *Atlas* provides a wind energy profile for selected locations representative of the different geographical areas of the state. It does not summarize all historical data from all Montana wind monitoring sites.

The *Montana Wind Energy Atlas* is organized as follows:

- Chapter I: Introduction
- Chapter II: Wind Monitoring Programs in Montana
- Chapter III: Wind Energy Potential
- Chapter IV: Site-by-Site Wind Analyses
- Chapter V: Power Law Analyses

Chapter II is a discussion of wind energy measurement programs conducted in Montana. The information available from these programs is evaluated in terms of how well it represents a region, its overall quality, and the inter-site comparability of collection methods. A list of the more important monitoring sites is included, along with a map showing site locations, monitoring agencies, and durations of data collection.

Chapter III summarizes wind data analyses from a statewide perspective. Sites are ranked by wind energy potential. Detailed tables and generalized isopleth maps display average annual wind speed and average annual wind power.

Chapter IV presents a detailed site-by-site description and analysis of all sites included in the *Atlas*. For each site, the data collected are evaluated for the period of data coverage, the method of collection, and the quality of the data. Summaries of monthly and annual average wind speed and wind power density are presented.

For purposes of this *Atlas*, sites where the average annual wind speed is equal to or greater than 11 miles per hour are considered "high potential" sites. In the description of such sites, these additional data summaries are provided:

- Diurnal wind speed frequency distribution by season;
- Directional frequency and average speed (wind rose);
- Coefficients of the Weibull distribution.

Detailed descriptions of site characteristics also are presented for the high potential sites. These descriptions include information on current use of the site, availability of space for further development, ease of access, and proximity of the site to transmission lines, sensitive communications equipment, and aircraft corridors.

Additional data analyses for two sites — the Livingston Candidate Wind Turbine site and the

Montana Power Company Salem site — where wind speed data gathered at more than one height above ground level were available, are presented in Chapter V. Variations in wind speed with height were analyzed for these sites.

Four appendices are included in this *Atlas*. Appendix A describes wind measurement procedures in general. Appendix B describes the methods used to gather and analyze the data. Appendix C briefly discusses sites for which data analyses are not presented. Appendix D is a bibliography listing wind energy resource information for Montana.

The *Atlas* was updated in 1987. It originally contained data available to DNRC as of the beginning of 1983. The updated version has information on nine additional sites, and larger term data on eleven sites in the first edition of the *Atlas*. Many of these sites are high potential sites. DNRC hopes to continue to update and expand the *Atlas* in the future.

Wind Monitoring Programs in Montana

Most wind monitoring in Montana has been conducted by the following agencies:

- National Weather Service (NWS);
- Federal Aviation Administration (FAA);
- U.S. Air Force (USAF);
- Air Quality Bureau, Montana Department of Health and Environmental Sciences (AQB);
- U.S. Environmental Protection Agency (EPA);
- Bureau of Reclamation, U.S. Department of the Interior (BOR);
- Montana Department of Natural Resources and Conservation (DNRC);
- U.S. Department of Energy (DOE);
- Bonneville Power Administration (BPA)
- Western Area Power Administration (WAPA)
- Private companies.

These monitoring programs were established for various reasons: to provide wind information for aviation, agriculture, and general public use (NWS, USAF, FAA); to study the dispersion of air pollutants (AQB, EPA, private companies); and to investigate potential wind power applications (DNRC, Bureau of Reclamation, DOE, BPA, WAPA, private companies).

Because of the different objectives of these monitoring efforts, the data have been collected by different means and organized into different formats (see Appendix A for a discussion of wind measurement in general). The periods of monitoring, averaging times, and representativeness of the data vary among the different monitoring programs. Information on various Montana wind monitoring site locations, monitoring agencies, and monitoring duration are presented on Map II-1 and Tables II-1 and II-2. The site numbers on the map are referenced in the tables. The 1987 additions may be found at the end of the tables.

Other groups, such as the U.S. Forest Service, also have conducted some monitoring in Montana. Some of these programs are discussed in Appendix C.

NWS/FAA/USAF

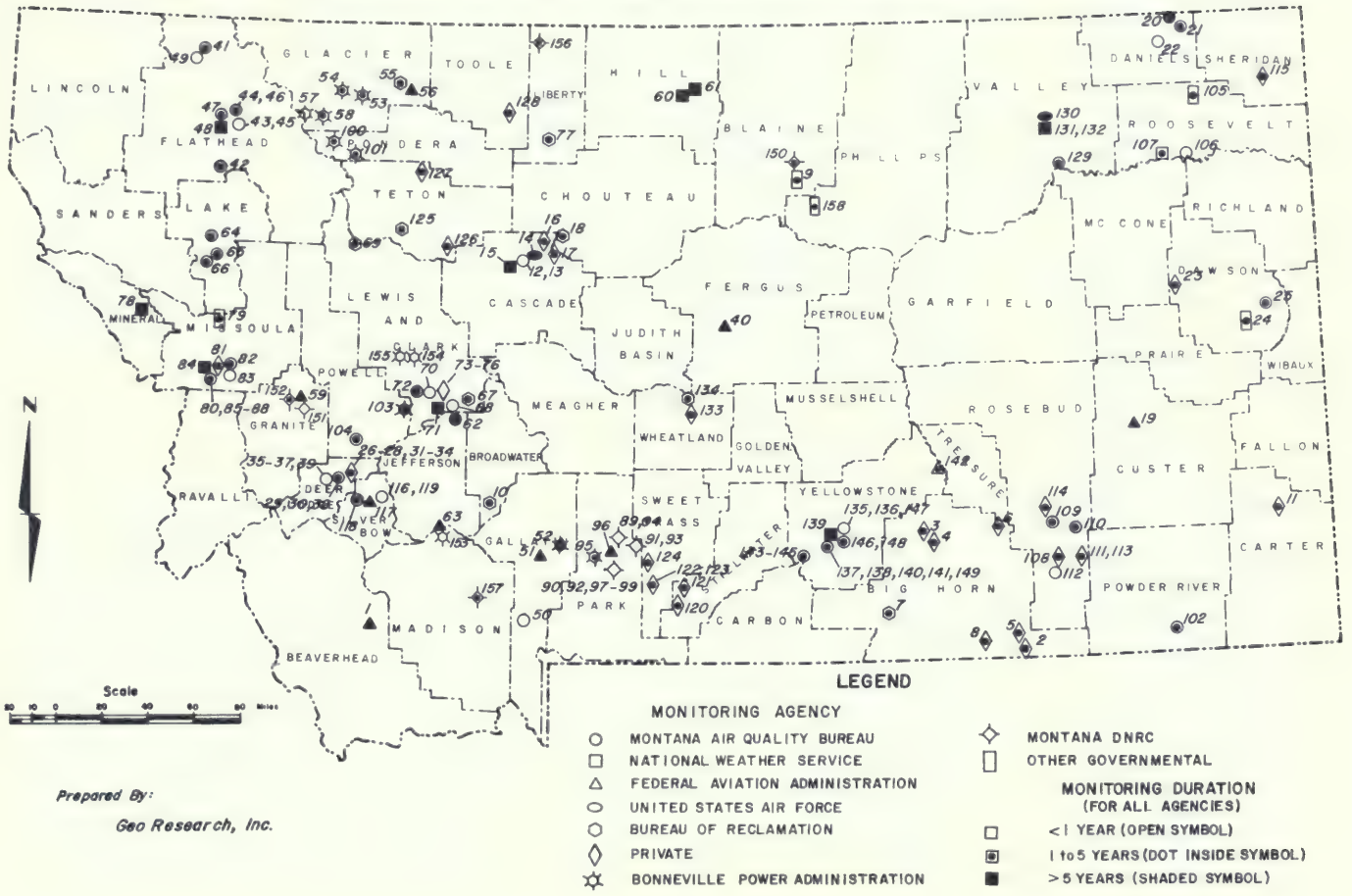
The National Weather Service is charged with providing weather-related services to aviation, agriculture, and the general public. To accomplish these tasks, the NWS, among other things, gathers meteorological data at several airports in Montana. The Federal Aviation Administration, to meet its responsibility to aviation, also collects meteorological data at many airports around the state. The United States Air Force has gathered similar data at Malmstrom Air Force Base and Glasgow Air Force Base. Over time, these agencies have assembled a large meteorological data base.

Data are taken hourly at NWS, FAA, and USAF airport stations. The meteorological parameters recorded include sky condition, visibility, barometric pressure, temperature, dewpoint, wind direction, wind speed, peak wind gust, and other significant data. The data are recorded approximately 10 minutes before each hour and are intended to represent a one-minute averaging period. Wind direction is read to the nearest 10 degrees, and wind speed is read to the nearest whole knot.

The advantages of the NWS, FAA, and USAF data are:

- They are available from a number of stations;
- The stations are distributed over a large geographic area;
- The data records typically are of many years' duration;
- The quality assurance program followed by the NWS, FAA, and USAF is good, so data accuracy is high;
- The data are readily available, both in hard copy and in machine-readable form.

Map II-1. Wind Monitoring Site Locations, Showing Monitoring Agencies and Durations



Prepared By:

Geo Research, Inc.

Table II-1. Wind Monitoring Site Locations

Site No.	Site Name	County	Location
1	Dillon FAA Airport	Beaverhead	45 15 00N 112 33 00W
	Dillon FAA Airport	Beaverhead	45 15 00N 112 33 00W
2	Decker Coal #8	Big Horn	45 03 19N 106 48 17W
3	Hardin	Big Horn	45 46 00N 107 49 00W
4	Hardin MDN	Big Horn	45 30 00N 107 30 00W
5	Spring Creek #1	Big Horn	45 07 02N 106 52 32W
6	Westmoreland Absaloka #2	Big Horn	45 46 27N 107 04 57W
7	Yellowtail Dam	Big Horn	45 19 06N 107 57 45W
8	Youngs Creek	Big Horn	45 02 00N 107 01 00W
9	Hays Forestry Shop	Blaine	45 55 44N 108 41 42W
10	Three Forks	Broadwater	45 59 20N 111 35 32W
11	Ekalaka	Carter	45 57 37N 104 25 18W
12	Great Falls City Sewage Pump	Cascade	47 30 00N 111 15 00W
13	Great Falls Kiwanis Park	Cascade	47 30 35N 111 16 32W
14	Great Falls Malmstrom Air Force Base	Cascade	47 31 12N 111 10 12W
	Great Falls Malmstrom Air Force Base	Cascade	47 31 12N 111 10 12W
	Great Falls Malmstrom Air Force Base	Cascade	47 31 12N 111 10 12W
15	Great Falls NWS Airport	Cascade	47 28 48N 111 22 12W
	Great Falls NWS Airport	Cascade	47 28 48N 111 22 12W
	Great Falls NWS Airport	Cascade	47 28 48N 111 22 12W
16	Portage	Cascade	47 35 00N 111 05 00W
17	Salem	Cascade	47 34 22N 111 02 34W
18	Highwood Bench	Chouteau	47 41 01N 110 54 02W
19	Miles City FAA Airport	Custer	46 25 48N 105 52 12W
	Miles City FAA Airport	Custer	46 25 48N 105 52 12W
20	Scobey Border	Daniels	49 00 00N 105 24 00W
21	Scobey Hanrahan	Daniels	48 53 47N 105 17 05W
22	Scobey Richardson	Daniels	48 48 35N 105 25 13W
23	Circle	Dawson	47 15 42N 105 16 05W
24	Glendive	Dawson	47 05 39N 104 43 01W
25	Glendive Microwave	Dawson	47 08 14N 104 32 45W
26	Anaconda #2 Pond Discharge	Deer Lodge	46 09 42N 112 46 57W
27	Anaconda C-Hill	Deer Lodge	46 06 03N 112 56 56W
28	Anaconda County Airport	Deer Lodge	46 08 45N 112 51 13W
29	Anaconda Highway Junction	Deer Lodge	46 08 09N 112 53 17W
30	Anaconda Lincoln School	Deer Lodge	46 07 31N 112 56 34W
31	Anaconda Mill Creek	Deer Lodge	46 06 19N 112 52 45W

Table II-1. Wind Monitoring Site Locations (cont'd.)

Site No.	Site Name	County	Location
32	Anaconda Water Office	Deer Lodge	46 08 51N 112 56 51W
33	Anaconda Weather Hill	Deer Lodge	46 05 51N 112 54 51W
34	Anaconda West Gate	Deer Lodge	46 06 03N 112 54 41W
35	Antelope	Deer Lodge	46 00 00N 113 00 00W
36	Kucera	Deer Lodge	46 00 00N 113 00 00W
37	Opportunity Main Street	Deer Lodge	46 08 45N 112 49 37W
38	Poor Farm	Deer Lodge	46 10 47N 112 52 46W
39	Tailings Pond	Deer Lodge	46 00 00N 113 00 00W
40	Lewistown FAA Airport	Fergus	47 03 00N 109 27 00W
	Lewistown FAA Airport	Fergus	47 03 00N 109 27 00W
41	Big Prairie	Flathead	48 48 29N 114 18 41W
42	Bigfork Ranger Station	Flathead	48 04 00N 114 05 57W
43	Columbia Falls Brandt	Flathead	48 18 22N 114 15 00W
44	Columbia Falls Delbon	Flathead	48 24 01N 114 08 21W
45	Columbia Falls Geis	Flathead	48 20 00N 114 08 30W
46	Columbia Falls Water Supply (Trailer)	Flathead	48 24 05N 114 08 32W
	Columbia Falls Water Supply	Flathead	48 24 05N 114 08 32W
47	Kalispell Airport	Flathead	48 18 38N 114 16 00W
48	Kalispell NWS Airport	Flathead	48 18 40N 114 16 00W
	Kalispell NWS Airport	Flathead	48 18 40N 114 16 00W
	Kalispell NWS Airport	Flathead	48 18 40N 114 16 00W
	Kalispell NWS Airport	Flathead	48 18 40N 114 16 00W
49	Polebridge	Flathead	48 45 53N 114 17 01W
50	Big Sky Golf Course	Gallatin	45 16 04N 111 17 23W
51	Bozeman FAA Airport	Gallatin	45 46 48N 111 09 00W
	Bozeman FAA Airport	Gallatin	45 46 48N 111 09 00W
52	Bridger Bowl	Gallatin	45 48 00N 111 05 30W
53	Blackfoot	Glacier	48 35 20N 112 52 35W
54	Browning RR Depot	Glacier	48 32 15N 113 01 00W
55	Cut Bank	Glacier	48 47 54N 112 19 37W
56	Cut Bank FAA Airport	Glacier	48 36 00N 112 22 12W
	Cut Bank FAA Airport	Glacier	48 36 00N 112 22 12W
57	Duck Lake	Glacier	48 50 20N 113 20 05W
58	Rainbow Field	Glacier	48 21 21N 113 08 10W
59	Drummond FAA Airport	Granite	46 37 10N 113 11 50W
	Drummond FAA Airport	Granite	46 37 10N 113 11 50W
60	Havre NWS Airport	Hill	48 33 00N 109 46 30W
	Havre NWS Airport	Hill	48 33 00N 109 46 30W
61	Havre NWS City Office	Hill	48 34 00N 109 40 00W

Table II-1. Wind Monitoring Site Locations (cont'd.)

Site No.	Site Name	County	Location
62	Microwave Tower	Jefferson	46 33 27N 111 55 01W
63	Whitehall FAA Airport	Jefferson	45 49 12N 112 12 00W
64	Polson	Lake	47 41 20N 114 07 27W
65	Ronan	Lake	47 30 54N 114 05 46W
66	Ronan Ninepipes	Lake	47 27 35N 114 07 59W
67	Canyon Ferry Dam	Lewis and Clark	46 43 54N 111 43 28W
68	East Helena A & W	Lewis and Clark	46 35 23N 111 54 25W
69	Gibson Dam	Lewis and Clark	47 37 47N 112 48 00W
70	Hadfield West Main	Lewis and Clark	46 35 18N 111 55 52W
71	Helena NWS Airport Helena NWS Airport	Lewis and Clark Lewis and Clark	46 36 21N 112 00 00W 46 36 21N 112 00 00W
72	Kleffner Residence	Lewis and Clark	46 00 00N 112 30 00W
73	Kleffner Road	Lewis and Clark	46 00 00N 112 30 00W
74	Sinter Plant	Lewis and Clark	46 34 39N 111 55 21W
75	Water Tower	Lewis and Clark	46 34 39N 111 55 21W
76	Zinc Plant	Lewis and Clark	46 34 39N 111 55 21W
77	Tiber Dam	Liberty	48 19 33N 111 04 47W
78	Superior NWS Airport	Mineral	47 10 48N 114 52 12W
79	Evaro	Missoula	47 02 00N 114 04 42W
80	Missoula Fire Lab	Missoula	46 33 00N 114 03 00W
81	Missoula Hoerner-Waldorf #1	Missoula	46 57 03N 114 10 35W
82	Missoula Lions Park	Missoula	46 51 05N 114 00 25W
83	Missoula Malfunction Junction	Missoula	46 51 07N 114 00 53W
84	Missoula NWS Airport Missoula NWS Airport Missoula NWS Airport	Missoula Missoula Missoula	46 55 40N 114 05 50W 46 55 40N 114 05 50W 46 55 40N 114 05 50W
85	Missoula Olofson	Missoula	46 49 49N 114 04 24W
86	Missoula Rose Park	Missoula	46 51 26N 114 00 14W
87	Missoula Stiegler	Missoula	46 54 15N 114 08 14W
88	Missoula University of Montana	Missoula	46 51 50N 113 58 40W
89	Charles Hillman Ranch	Park	45 43 24N 110 28 24W
90	George Meyers Ranch	Park	45 40 03N 110 32 10W
91	Gordon Brittan Ranch	Park	45 42 16N 110 23 37W
92	Harvatts Flat	Park	45 38 55N 110 32 35W
93	Hunters Hot Springs	Park	45 45 16N 110 15 38W
94	Koffee Kup Ranch	Park	45 46 38N 110 30 54W

Table II-1. Wind Monitoring Site Locations (cont'd.)

Site No.	Site Name	County	Location
95	Livingston Candidate Wind Turbine Site	Park	45 40 27N 110 30 01W
96	Livingston FAA Airport Livingston FAA Airport	Park Park	45 40 12N 110 31 48W 45 40 12N 110 31 48W
97	Livingston West	Park	45 39 23N 110 34 37W
98	McGuire Hill	Park	45 40 23N 110 33 53W
99	Park County Landfill	Park	45 40 07N 110 31 12W
100	Heart Butte	Pondera	48 17 42N 112 53 03W
101	Swift Dam	Pondera	48 13 15N 112 47 00W
102	Broadus Randall Ranch	Powder River	45 24 27N 105 27 50W
103	McDonald Pass	Powell	46 35 42N 112 17 05W
104	Powell County Courthouse	Powell	46 23 49N 112 43 39W
105	Give Out Morgan	Roosevelt	48 28 24N 105 07 54N
106	Poplar	Roosevelt	48 06 10N 105 11 55W
107	Wolf Point	Roosevelt	48 05 00N 105 32 00W
108	Badger Peak	Rosebud	45 38 58N 106 33 23W
109	Colstrip BN	Rosebud	45 51 30N 106 34 43W
110	Colstrip McRae	Rosebud	45 45 47N 106 23 09W
111	Garfield Peak	Rosebud	45 40 08N 106 27 54W
112	Lame Deer-Fisher Butte	Rosebud	45 37 34N 106 39 14W
113	Morningstar Lookout	Rosebud	45 40 06N 106 31 04W
114	Western Energy #12	Rosebud	45 52 06N 106 38 27W
115	Reserve	Sheridan	48 30 58N 104 18 23W
116	Butte Alpine West	Silver Bow	46 00 45N 112 30 32W
117	Butte FAA Airport	Silver Bow	45 57 00N 112 30 00W
118	Butte Hebgen Park	Silver Bow	46 00 13N 112 31 29W
119	Harrison Fire Station	Silver Bow	46 00 00N 112 30 00W
120	Anaconda Stillwater Mine Site	Stillwater	45 25 30N 109 53 11W
121	Hertzler Ranch	Stillwater	45 32 26N 109 47 10W
122	Long Mountain	Sweetgrass	45 32 20N 110 05 01W
123	Main Station	Sweetgrass	45 30 37N 110 06 07W
124	Woolsey Ranch	Sweetgrass	45 35 05N 110 06 37W
125	Choteau	Teton	47 44 36N 112 26 05W
126	Fairfield	Teton	47 36 31N 112 02 43W
127	Pendroy	Teton	48 07 45N 112 26 20W
128	Devon	Toole	48 26 00N 111 27 00W

Table II-1. Wind Monitoring Site Locations (cont'd.)

Site No.	Site Name	County	Location
129	Fort Peck	Valley	47 59 48N 106 29 59W
130	Glasgow Air Force Base	Valley	48 24 00N 106 31 20W
	Glasgow Air Force Base	Valley	48 24 00N 106 31 20W
	Glasgow Air Force Base	Valley	48 24 00N 106 31 20W
131	Glasgow NWS Airport	Valley	48 13 12N 106 37 12W
	Glasgow NWS Airport	Valley	48 13 12N 106 37 12W
	Glasgow NWS Airport	Valley	48 13 12N 106 37 12W
132	Glasgow NWS City Office	Valley	48 11 00N 106 38 00W
133	Harlowton	Wheatland	46 28 00N 109 52 00W
134	Judith Gap	Wheatland	46 36 57N 109 46 11W
135	Billings AQB Office	Yellowstone	45 46 57N 108 31 56W
136	Billings 11th & 27th	Yellowstone	45 46 18N 108 29 57W
137	Billings Central Park	Yellowstone	45 46 51N 108 32 19W
138	Billings Metra	Yellowstone	45 47 55N 108 28 45W
139	Billings NWS Airport	Yellowstone	45 48 00N 108 31 48W
	Billings NWS Airport	Yellowstone	45 48 00N 108 31 48W
	Billings NWS Airport	Yellowstone	45 48 00N 108 31 48W
140	Billings Taft School	Yellowstone	45 46 36N 108 29 40W
141	Coburn Road	Yellowstone	45 47 00N 108 28 00W
142	Custer FAA Airport	Yellowstone	46 09 00N 107 31 00W
	Custer FAA Airport	Yellowstone	46 09 00N 107 31 00W
143	Laurel BN	Yellowstone	45 41 00N 108 42 00W
144	Laurel Farm	Yellowstone	45 39 39N 108 46 12W
145	Laurel New Farm	Yellowstone	45 40 07N 108 44 25W
146	Lockwood Park	Yellowstone	45 48 00N 108 27 00W
147	Lockwood School	Yellowstone	45 47 57N 108 26 30W
148	North Johnson Lane	Yellowstone	45 49 00N 108 26 00W
149	Shawnee Park	Yellowstone	45 49 28N 108 23 56W
1987 Additions			
150	Hays	Blaine	48 06 17N 108 42 43W
151	Drummond—1	Granite	46 37 00N 113 11 00W
152	Drummond—2	Granite	46 39 52N 113 15 06W
153	Whitehall	Jefferson	45 55 57N 112 04 30W
154	Sieben 1	Lewis and Clark	46 55 00N 112 13 00W
155	Sieben 2	Lewis and Clark	46 50 30N 112 15 30W
156	Whitlash	Liberty	48 51 36N 111 14 46W
157	Norris Hill	Madison	45 29 42N 111 41 57W
158	Mt. Antione	Phillips	47 57 20N 108 33 02W

Table II-2. Monitoring Agency and Duration

Site No.	Site Name	Monitoring Agency	Duration of Monitoring
1	Dillon FAA Airport	Federal Aviation Administration	1951 JUN 19 - 1963 OCT 29
	Dillon FAA Airport	Federal Aviation Administration	1963 OCT 30 - 1973 JUN 18
2	Decker Coal #8	Decker Coal Company	1980 DEC 01 - 1982 MAY 31
3	Hardin	Montana Power Company	1980 MAY - 1981 APR
4	Hardin MDN	Air Quality Bureau	1972 APR - 1973 JUL
5	Spring Creek #1	Spring Creek Coal Company	1981 JAN 01 - 1981 DEC 31
6	Westmoreland Absaloka #2	Westmoreland Resources, Inc.	1980 AUG 01 - 1982 MAR 29
7	Yellowtail Dam	Bureau of Reclamation	1980 JAN 21 - 1981 JAN 31
8	Youngs Creek	Shell Oil Company	1975 OCT - 1979 DEC
9	Hays Forestry Shop	Fort Belknap Reservation	1980 AUG - ?
10	Three Forks	Bureau of Reclamation	1981 JUN 27 - 1982 SEP 15
11	Ekalaka	Southeast Electric Co-op	1982 MAR 11 - 1986 MAY 18
12	Great Falls City Sewage Pump	Air Quality Bureau	1972 JUN - 1972 AUG
13	Great Falls Kiwanis Park	Air Quality Bureau	1980 JAN 01 - 1980 FEB 16
14	Great Falls Malmstrom Air Force Base	United States Air Force	1949 JAN 01 - 1953 MAY 31
	Great Falls Malmstrom Air Force Base	United States Air Force	1954 MAR 01 - 1958 FEB 28
	Great Falls Malmstrom Air Force Base	United States Air Force	1958 APR 01 - 1968 NOV 30
15	Great Falls NWS Airport	National Weather Service	1948 JAN 01 - 1959 FEB 02
	Great Falls NWS Airport	National Weather Service	1959 FEB 03 - 1964 DEC 31
	Great Falls NWS Airport	National Weather Service	1965 JAN 01 - 1978 DEC 31
16	Portage	Montana Power Company	1980 APR - ?
17	Salem	Montana Power Company	1980 MAY 01 - 1984 MAR
18	Highwood Bench	Bureau of Reclamation	1981 JUN 05 - 1983 JUN 17
19	Miles City FAA Airport	Federal Aviation Administration	1948 JAN 01 - 1964 DEC 31
	Miles City FAA Airport	Federal Aviation Administration	1965 JAN 01 - 1978 DEC 31
20	Scobey Border	Air Quality Bureau	1977 MAR 02 - 1982 APR 26
21	Scobey Hanrahan	Air Quality Bureau	1981 APR 01 - 1982 MAR 31
22	Scobey Richardson	Air Quality Bureau	1979 JAN 16 - 1979 MAY 31
23	Circle	McCone Electric Co-op	1982 MAR 11 - 1985 OCT 30
24	Glendive	Environmental Protection Agency	1974 DEC 26 - 1976 FEB 29
25	Glendive Microwave	Air Quality Bureau	1975 JUL 26 - 1977 SEP 14
26	Anaconda #2 Pond Discharge	Anaconda Copper Company	1976 DEC 04 - 1979 MAY 31
27	Anaconda C-Hill	Anaconda Copper Company	1976 JAN 01 - 1979 MAY 31
28	Anaconda County Airport	Anaconda Copper Company	1976 DEC 04 - 1979 MAY 31
29	Anaconda Highway Junction	Air Quality Bureau	1975 JUN 11 - 1979 DEC 28
30	Anaconda Lincoln School	Air Quality Bureau	1978 JUL 03 - 1981 MAY 19
31	Anaconda Mill Creek	Anaconda Copper Company	1976 DEC 04 - 1979 MAY 31
32	Anaconda Water Office	Anaconda Copper Company	1976 DEC 04 - 1979 MAY 31
33	Anaconda Weather Hill	Anaconda Copper Company	1976 DEC 04 - 1979 MAY 31

Table II-2. Monitoring Agency and Duration (cont'd.)

Site No.	Site Name	Monitoring Agency	Duration of Monitoring
34	Anaconda West Gate	Anaconda Copper Company	1976 JAN 01 - 1979 MAY 31
35	Antelope	Air Quality Bureau	1973 FEB - 1973 AUG
36	Kucera	Air Quality Bureau	1972 DEC - 1973 MAY
37	Opportunity Main Street	Air Quality Bureau	1972 JUN - 1972 NOV
38	Poor Farm	Air Quality Bureau	1971 DEC - 1973 JAN
39	Tailings Pond	Air Quality Bureau	1974 JUL - 1974 OCT
40	Lewistown FAA Airport	Federal Aviation Administration	1949 DEC 21 - 1962 AUG 15
	Lewistown FAA Airport	Federal Aviation Adminsitration	1964 OCT 13 - 1978 DEC 31
41	Big Prairie	Air Quality Bureau	1978 NOV 07 - 1982 JAN 04
42	Bigfork Ranger Station	Air Quality Bureau	1979 NOV 16 - 1980 JUN 10
	Bigfork Ranger Station	Air Quality Bureau	1981 JUL 15 - 1981 AUG 30
43	Columbia Falls Brandt	Air Quality Bureau	1977 MAR 02 - 1977 JUN 06
	Columbia Falls Brandt	Air Quality Bureau	1978 MAR 17 - 1978 MAY 29
44	Columbia Falls Delbon	Air Quality Bureau	1977 MAR 14 - 1978 MAY 31
45	Columbia Falls Geis	Air Quality Bureau	1978 JAN - 1978 MAY
46	Columbia Falls Water Supply (Trailer)	Air Quality Bureau	1972 FEB - 1974 JUN
	Columbia Falls Water Supply	Air Quality Bureau	1977 FEB 16 - 1979 OCT 22
47	Kalispell Airport	Air Quality Bureau	1976 DEC 21 - 1977 OCT 20
	Kalispell Airport	Air Quality Bureau	1978 JUN 23 - 1982 FEB 15
48	Kalispell NWS Airport	National Weather Service	1949 MAY 01 - 1953 JUN 30
	Kalispell NWS Airport	National Weather Service	1953 JUL 01 - 1959 JUN 30
	Kalispell NWS Airport	National Weather Service	1959 JUL 01 - 1964 JUN 30
	Kalispell NWS Airport	National Weather Service	1964 JUL 01 - 1978 DEC 31
49	Polebridge	Air Quality Bureau	1978 SEP 14 - 1978 NOV 07
50	Big Sky Golf Course	Air Quality Bureau	1981 JUL 03 - 1982 MAY 15
51	Bozeman FAA Airport	Federal Aviation Administration	1948 JAN 01 - 1951 APR 27
	Bozeman FAA Airport	Federal Aviation Administration	1951 APR 28 - 1954 DEC 31
52	Bridger Bowl	U.S. Forest Service	1968 - 1983 APR
53	Blackfoot	Bonneville Power Administration	1981 SEP - 1984 JUL
	Blackfoot	Bonneville Power Administration	1984 JUL 30 - 1985 OCT 29
54	Browning RR Depot	Burlington Northern	1981 APR - 1983 APR
55	Cut Bank	Bureau of Reclamation	1981 JUN 03 - 1983 AUG 3
56	Cut Bank FAA Airport	Federal Aviation Administration	1949 NOV 22 - 1959 OCT 03
	Cut Bank FAA Airport	Federal Aviation Administration	1959 OCT 04 - 1978 DEC 31
57	Duck Lake	Bonneville Power Administration	1982 NOV - 1984 APR
58	Rainbow Field	Bonneville Power Administration	1981 SEP - 1982 NOV
59	Drummond FAA Airport	Federal Aviation Administration	1948 JAN 01 - 1950 OCT 15
	Drummond FAA Airport	Federal Aviation Administration	1950 OCT 16 - 1954 DEC 31
60	Havre NWS Airport	National Weather Service	1961 FEB 01 - 1964 DEC 31
	Havre NWS Airport	National Weather Service	1967 JAN 01 - 1978 DEC 31
61	Havre NWS City Office	National Weather Service	1950 MAY 01 - 1956 OCT 31
62	Microwave Tower	Air Quality Bureau	1975 JAN 16 - 1981 DEC 31
63	Whitehall FAA Airport	Federal Aviation Administration	1948 JAN 01 - 1954 DEC 31

Table II-2. Monitoring Agency and Duration (cont'd.)

Site No.	Site Name	Monitoring Agency	Duration of Monitoring
64	Polson	Air Quality Bureau	1978 OCT 19 - 1980 SEP 17
	Polson	Air Quality Bureau	1981 MAR 01 - 1981 DEC 05
65	Ronan	Air Quality Bureau	1979 JAN 03 - 1980 JUN 15
66	Ronan Ninepipes	Air Quality Bureau	1980 DEC 11 - 1982 FEB 26
67	Canyon Ferry Dam	Bureau of Reclamation	1980 JAN 31 - 1981 JAN 31
68	East Helena A & W	Air Quality Bureau	1980 FEB 01 - 1980 JUN 30
69	Gibson Dam	Bureau of Reclamation	1980 JAN 15 - 1981 JAN 31
70	Hadfield West Main	Air Quality Bureau	1981 OCT 01 - 1981 DEC 31
71	Helena NWS Airport	National Weather Service	1948 JAN 01 - 1961 SEP 19
	Helena NWS Airport	National Weather Service	1961 SEP 20 - 1978 DEC 31
72	Kleffner Residence	Air Quality Bureau	1968 JUL - 1971 SEP
73	Kleffner Road	ASARCO	1981 OCT 01 - 1981 DEC 31
74	Sinter Plant	ASARCO	1981 OCT 01 - 1981 DEC 31
75	Water Tower	ASARCO	1981 OCT 01 - 1981 DEC 31
76	Zinc Plant	ASARCO	1981 OCT 01 - 1981 DEC 31
77	Tiber Dam	Bureau of Reclamation	1980 JAN 16 - 1981 JAN 31
78	Superior NWS Airport	National Weather Service	1948 JAN 01 - 1953 NOV 30
79	Evaro	Flathead Reservation	1980 OCT - ?
80	Missoula Fire Lab	Air Quality Bureau	1977 DEC 01 - 1980 APR 30
81	Missoula Hoerner-Waldorf #1	Hoerner-Waldorf	1977 JUL 01 - 1982 MAR 31
82	Missoula Lions Park	Air Quality Bureau	1977 DEC 02 - 1980 JUL 27
83	Missoula Malfunction Junction	Air Quality Bureau	1980 APR 03 - 1980 MAY 26
84	Missoula NWS Airport	National Weather Service	1948 JAN 01 - 1958 APR 03
	Missoula NWS Airport	National Weather Service	1958 APR 04 - 1964 DEC 31
	Missoula NWS Airport	National Weather Service	1965 JAN 01 - 1978 DEC 31
85	Missoula Olofson	Air Quality Bureau	1978 JUL 15 - 1980 MAR 17
86	Missoula Rose Park	Air Quality Bureau	1980 NOV 14 - 1982 APR 26
87	Missoula Stiegler	Air Quality Bureau	1978 MAY 01 - 1980 MAR 17
88	Missoula University of Montana	Air Quality Bureau	1978 MAY 01 - 1980 MAR 17
89	Charles Hillman Ranch	Montana DNRC	1979 MAR - 1979 APR
90	George Meyers Ranch	Montana DNRC	1979 MAR - 1979 APR
91	Gordon Brittan Ranch	Montana DNRC	1979 MAY - 1979 JUL
92	Harvatts Flat	Montana DNRC	1978 DEC - 1979 FEB
93	Hunters Hot Springs	Montana DNRC	1978 DEC - 1979 FEB
94	Koffee Kup Ranch	Montana DNRC	1978 DEC - 1979 FEB
95	Livingston Candidate Wind Turbine Site	Bonneville Power Administration	1980 SEP 01 - 1982 JUN 30
96	Livingston FAA Airport	Federal Aviation Administration	1948 JAN 01 - 1953 JUL 04
	Livingston FAA Airport	Federal Aviation Administration	1953 JUL 05 - 1954 DEC 31

Table II-2. Monitoring Agency and Duration (cont'd.)

Site No.	Site Name	Monitoring Agency	Duration of Monitoring
97	Livingston West	Montana DNRC	1979 MAY - 1979 JUL
98	McGuire Hill	Montana DNRC	1979 MAY - 1979 JUL
99	Park County Landfill	Montana DNRC	1979 MAR - 1979 APR
100	Heart Butte	Bonneville Power Administration	1981 SEP - 1982 OCT
	Heart Butte	Bonneville Power Administration	1982 NOV 13 - 1984 MAY 29
101	Swift Dam	Bonneville Power Administration	1981 SEP - 1984 JUN
102	Broadus Randall Ranch	Air Quality Bureau	1976 MAR 06 - 1978 AUG 27
103	McDonald Pass	Bonneville Power Administration	1981 OCT - 1982 DEC
104	Powell County Courthouse	Air Quality Bureau	1971 APR - 1972 MAY
105	Give Out Morgan	Fort Peck Reservation	1980 AUG - ?
106	Poplar	Air Quality Bureau	1976 MAY 18 - 1976 SEP 30
107	Wolf Point	National Weather Service	1958 JAN - 1962 DEC
108	Badger Peak	GeoResearch, Inc. (MPC/NCT)	1981 APR 01 - Present
109	Colstrip BN	Air Quality Bureau	1975 JAN 01 - 1979 AUG 22
110	Colstrip McRae	Air Quality Bureau	1975 JAN 01 - 1976 AUG 04
111	Garfield Peak	GeoResearch, Inc. (MPC/NCT)	1981 APR 01 - Present
112	Lame Deer-Fisher Butte	Air Quality Bureau	1976 MAY 16 - 1976 OCT 26
113	Morningstar Lookout	GeoResearch, Inc. (MPC/NCT)	1981 APR 01 - Present
114	Western Energy #12	Western Energy Company	1981 JAN 01 - 1982 MAR 31
115	Reserve	Sheridan Electric Co-op	1982 JAN 29 - 1985 JUN 30
116	Butte Alpine West	Air Quality Bureau	1977 AUG 01 - 1978 JUN 15
117	Butte FAA Airport	Federal Aviation Administration	1948 JAN 01 - 1960 DEC 31
118	Butte Hebgen Park	Air Quality Bureau	1978 JUN 15 - 1980 DEC 10
119	Harrison Fire Station	Air Quality Bureau	1972 JAN - 1972 MAR
120	Anaconda Stillwater Mine Site	Anaconda Minerals Company	1980 AUG - 1981 JUL
121	Hertzler Ranch	Anaconda Minerals Company	1980 AUG - 1981 JUL
122	Long Mountain	PGM Resources	1981 OCT - 1982 SEP
123	Main Station	PGM Resources	1981 OCT - 1982 SEP
124	Woolsey Ranch	PGM Resources	1981 OCT - 1982 SEP
125	Choteau	Bureau of Reclamation	1981 JUN 04 - 1983 AUG 16
126	Fairfield	Sun River Electric Co-op	1981 DEC 30 - 1985 JAN 3
127	Pendroy	Sun River Electric Co-op	1982 MAR 17 - 1984 DEC 19
128	Devon	Montana Power Company	1980 APR - 1981 APR
129	Fort Peck	Air Quality Bureau	1977 MAY 07 - 1979 JUL 19
130	Glasgow Air Force Base	United States Air Force	1958 OCT 01 - 1961 JUN 07
	Glasgow Air Force Base	United States Air Force	1961 JUN 08 - 1968 JUN 30
	Glasgow Air Force Base	Old West Regional Commission	1977 OCT 25 - 1978 AUG 31

Table II-2. Monitoring Agency and Duration (cont'd.)

Site No.	Site Name	Monitoring Agency	Duration of Monitoring
131	Glasgow NWS Airport	National Weather Service	1955 OCT 01 - 1962 AUG 05
	Glasgow NWS Airport	National Weather Service	1962 AUG 06 - 1968 MAY 31
	Glasgow NWS Airport	National Weather Service	1968 JUN 01 - 1978 DEC 31
132	Glasgow NWS City Office	National Weather Service	1948 JAN 01 - 1955 OCT 31
133	Harlowton	Electric Power Research Institute	1981 JUN - 1982 OCT
134	Judith Gap	Bureau of Reclamation	1981 AUG 01 - 1985 JUL 31
135	Billings AQB Office	Air Quality Bureau	1970 JUN - 1971 APR
136	Billings 11th & 27th	Air Quality Bureau	1975 SEP 21 - 1976 APR 30
137	Billings Central Park	Air Quality Bureau	1978 AUG 10 - 1980 MAY 08
138	Billings Metra	Air Quality Bureau	1980 SEP 13 - 1982 MAY 03
139	Billings NWS Airport	National Weather Service	1948 JAN 01 - 1958 JUN 25
	Billings NWS Airport	National Weather Service	1958 JUN 26 - 1964 DEC 31
	Billings NWS Airport	National Weather Service	1965 JAN 01 - 1978 DEC 31
140	Billings Taft School	Air Quality Bureau	1980 AUG 07 - 1982 MAY 17
141	Coburn Road	Air Quality Bureau	1981 SEP - 1982 SEP
142	Custer FAA Airport	Federal Aviation Administration	1948 JAN 01 - 1949 MAY 31
	Custer FAA Airport	Federal Aviation Administration	1949 JUN 01 - 1950 MAY 30
143	Laurel BN	Air Quality Bureau	1981 SEP - 1982 SEP
144	Laurel Farm	Air Quality Bureau	1976 MAY 01 - 1980 JUL 15
145	Laurel New Farm	Air Quality Bureau	1980 NOV 13 - 1982 MAY 17
146	Lockwood Park	Air Quality Bureau	1981 SEP - 1982 SEP
147	Lockwood School	Air Quality Bureau	1979 AUG 02 - 1980 JUN 11
148	North Johnson Lane	Air Quality Bureau	1981 SEP - 1982 SEP
149	Shawnee Park	Air Quality Bureau	1981 JAN 22 - 1982 APR 30
1987 Additions			
150	Hays	Montana DNRC	1984 JAN 1 - 1985 JUL 15
151	Drummond—1	Montana DNRC	1982 DEC 17 - 1983 JUL 26
152	Drummond—2	Montana DNRC	1983 DEC 2 - 1985 MAY 29
153	Whitehall	Bonneville Power Administration	1983 SEP - 1984 JUL
154	Sieben 1	Bonneville Power Administration	1984 FEB 18 - 1984 JUL 28
155	Sieben 2	Bonneville Power Administration	1983 OCT - 1984 JUL
156	Whitlash	Montana DNRC	1983 NOV 18 - 1985 JUL 24
157	Norris Hill	Montana DNRC	1984 JAN 10 - 1986 MAR 31
158	Mt. Antione	WAPA	1984 FEB 8 - 1985 AUG 5

NOTE: The monitoring duration represents the full or known period of monitoring at a given site, or the period for which data were available to DNRC. Sites at which monitoring is continuing, but data were not available, are marked "present"; sites for which the status is unknown are marked "?".

The disadvantages of these data are:

- The values of wind speed and direction are approximately 1-minute averages, so users must be cautious when comparing them to other data sets;
- Anemometer heights are not standardized in most cases;
- Particularly in earlier years, the anemometers were located on rooftops; such an exposure creates the possibility that the wind speed values recorded were too high, due to acceleration of air over the buildings;
- The stations are located at airports and/or urban areas, which typically are areas where high winds occur less frequently.

In spite of these deficiencies, the NWS, FAA, and USAF data are a valuable resource for evaluating potential wind power.

Data from these sources are gathered and stored by the National Climatic Center (NCC) in Asheville, North Carolina. This data set has been analyzed by Battelle Pacific Northwest Laboratories, and a Wind Energy Data Base has been assembled. The data base consists of several data files:

- Station Description — physical characteristics of the station;
- Means and Frequency Distribution — mean wind speed and wind energy flux, as well as wind speed frequency distributions;
- Intra-/Inter-Annual — monthly and annual means and standard deviations of wind speed, wind energy flux, and other parameters;
- Climatic Means and Weather Events — monthly means of air density, temperature and pressure, and occurrences of significant weather events;
- Persistence of Speed and Direction — number of episodes of given duration when the wind speed exceeded a threshold or the wind direction remained constant;
- Wind Data Grid — wind energy flux, land surface form, resource certainty rating, and resource areal distribution by grid cell.

These files were obtained from Battelle, and portions of the data files were incorporated into the *Montana Wind Energy Atlas.*

The data that Battelle obtained from NCC consisted of either summarized, digitized, or unsummarized data from NWS, FAA, and USAF airport stations. The NWS and FAA data obtained by Battelle were collected from 1948 through 1978, except for those sites where monitoring was discontinued at an earlier date. The USAF data obtained by Battelle were collected from 1948 through 1968, when the USAF stopped coding their meteorological data for the NCC. All NCC data originally are in unsummarized formats consisting of the original station weather records. The data for some stations have been analyzed by NCC and condensed into wind summaries. Data from some airport stations have been digitized by NCC and made available in machine-readable form.

When Battelle conducted its analyses, it used summarized or digitized data whenever possible. If both summarized and digitized data were available, the digitized data were used to prepare a more extensive characterization of the wind resource. Unsummarized data were used only when no summarized or digitized data were available.

For stations with digitized data, Battelle calculated the average wind power density from:

$$\overline{P} = \frac{1}{2n} \sum_{i=1}^{n} \rho_i V_i^3$$

where:

- n = the number of observations in the averaging period;
- ρ_i = the density (in kg/m^3) computed from the station pressure and temperature;
- V_i = the wind speed (in m/s) at the i th observation time.

For stations with wind summaries, $\overline{P}$ was calculated from:

$$\overline{P} = \frac{1}{2} \overline{\rho} \sum_{j=1}^{c} f_j V_j^3$$

where:

- $\overline{\rho}$ = the mean air density;
- c = the number of wind speed classes;
- f_j = frequency of occurrence of winds in the j th class;
- V_j = the median wind speed of the j th class.

In those cases for which unsummarized wind data were assessed, the seasonal and annual average speeds, $\overline{V}$, were estimated from a visual examination of one year's original weather records. The wind power density, $\overline{P}$, then was estimated by assuming the speed frequency distribution followed a Rayleigh distribution. (A Rayleigh distribution is a mathematical approximation of actual wind speed distributions; see Appendix B.) The wind power density was calculated as follows:

$$\overline{P} = 0.955 \, \overline{\rho} \, \overline{V}^3$$

Battelle also adjusted the long-term mean wind speed and wind power density to a reference level of 10 meters by means of the one-seventh power law. In the data tables presented in this *Atlas,* the mean wind speeds and wind power densities presented are for the anemometer height, and have not been adjusted to a reference height.

Montana Air Quality Bureau

The Montana Air Quality Bureau (AQB) is responsible for monitoring air quality in the state and for safeguarding the public health. To accomplish these goals, the AQB operates a number of air monitoring stations around the state. In addition, the AQB has conducted special studies, such as the Montana Air Pollution Study and the Flathead River Basin Environmental Impact Study, to evaluate meteorological conditions and air quality in specific areas.

The AQB also requires operators of certain facilities, such as power plants and smelters, to conduct monitoring programs around their projects. The data thus collected are submitted to the AQB and become part of AQB's data file.

During the past 10 years, the AQB has accumulated a large amount of meteorological data. The advantages of these data are:

- The data were collected from a large number of sites;
- The sites are distributed over a large geographic area;
- The data represent a one-hour averaging time;
- The data are readily available, in SAROAD format, in hard copy or in machine-readable form (SAROAD is the Environmental Protection Agency's standard format for coding aerometric data).

The disadvantages of these data are:

- In most cases, the monitoring period was short (less than three years);
- Anemometer heights were not standardized until recently;
- The data set, especially for earlier years, contains a significant number of errors;
- In many cases, the data are not very complete;
- The quality assurance program for meteorological data was inadequate until recently; in particular, alignment of wind direction sensors sometimes was inaccurate;
- Many of the stations were located in urban areas.

U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) has, from time to time, conducted wind monitoring studies in Montana. These studies generally were conducted as a part of studies of dispersion around sources of pollution. One such study, which was designed to study sulfur dioxide concentrations in the air near East Helena, was conducted in 1969 and 1970. Another study was conducted near Glendive in 1975 and 1976. The EPA also is a major source of funds for other agencies, such as the AQB, which conduct studies of their own. For example, two major monitoring studies conducted by the AQB, the Flathead River Basin Environmental Impact Study and the Poplar River Study, were funded largely by EPA.

Bureau of Reclamation, U.S. Department of Interior

The Bureau of Reclamation (BOR), in recent years, has initiated studies to identify areas of high potential for wind energy generation. The Northern Great Plains Wind Energy Study is one such monitoring effort. Wind monitoring sites were established at 15 sites in Montana, North Dakota, South Dakota, and Wyoming. The BOR provided the Montana data for inclusion in the *Montana Wind Energy Atlas.*

The data set contains the following information:

- Average hourly wind speed;
- Maximum wind speed during the hour;
- Minimum wind speed during the hour;
- Average cube of the hourly wind speed;
- Standard deviation of the hourly speed;
- Wind direction.

The data were recorded on cassette tape by a computerized data acquisition system. The tapes were further processed by computer to yield the completed data set.

The advantages of these data are:

- The sites were located in areas of high wind potential;
- Parameters of interest to wind developers were monitored;
- Anemometer heights were standardized;
- The data are readily available, either in hard copy or machine-readable form.

Monitoring continued at these sites for at least two years.

Montana Department of Natural Resources and Conservation

The Montana Department of Natural Resources and Conservation (DNRC) assumed responsibility for operating the BOR wind monitoring sites in Montana in 1982. The monitoring equipment later was moved to other sites. Since 1982, DNRC has completed monitioring the wind at four sites and plans to continue monitoring at four other sites (Augusta, Norris Hill, Ringling, and Whitehall) at least through June 1987. BOR has provided data reduction services and issued quarterly reports for these sites.

DNRC, through its Renewable Energy Program, has funded other wind monitoring efforts around the state. Among these studies are the Wind Energy Survey (Livingston to Springdale) and the Montana Wind Energy Research and Development Program.

The advantages of these data are:

- The sites have been located in areas of high wind potential;
- The studies were specifically designed to provide data for wind energy applications;
- Anemometer heights were standardized.

The only disadvantage of these data is that the monitoring periods were short, generally a few months to a year.

In 1985, DNRC funded wind monitoring outside of Anaconda and across the Livingston bench, as well as a wind shear study in Livingston at the old Candidate Wind Turbine Site.

U.S. Department of Energy

The Department of Energy (DOE), as part of various federal energy programs, conducted research activities to provide information on wind characteristics throughout the United States. These efforts included:

- Wind Energy Resource Assessment;
- Siting Methodologies;
- Meteorological Characteristics for Design and Performance Evaluation;
- Meteorological Characteristics for Wind Energy Conversion System Operations;
- Site Selection Support;
- Site Meteorological Measurements;
- Large Machine Site Evaluation.

As part of this program, DOE collected wind data at the Livingston Candidate Wind Turbine site since September 1980. This monitoring effort was taken over by the Bonneville Power Administration in October 1982 through June 1983.

The data collected at Livingston consist of hourly averages of wind speed and wind direction at three different anemometer heights (10, 30, and 45.7 meters above ground level). The data were recorded digitally at the site on a data cassette recording system. An instantaneous sample of data was recorded every two minutes. These data are summarized in the *Montana Wind Energy Atlas.*

The advantages of these data are:

- The site is located in an area of high wind energy potential;
- Data were collected at three different anemometer heights;
- The data set is nearly complete;
- The system was designed specifically to provide data for wind energy applications;
- The data are readily available, either in hard copy or in machine-readable form.

Bonneville Power Administration

The Bonneville Power Administration (BPA) in 1980 initiated the Wind Regional Energy Assessment Program (Wind REAP). This five-year program was designed to assess the wind resource potential throughout the Pacific Northwest. The actual research was carried out by Oregon State University. The program consisted of fly-overs of areas to identify high potential sites and later location of wind monitoring devices at some of those sites. Nine sites were instrumented in Montana.

The advantages of these data are:

- The sites were located in areas of high wind potential;
- Most of the anemometers were set at a standard height of 30 feet;
- The data are readily available in hard copy and data for three sites are available in machine-readable form;
- Information on the suitability of the sites for wind farm development was collected.

The disadvantages of the data are:

- Only wind-run data were collected at six of the sites, and at two of the other three, only wind-run data were collected for most of the time they were in operation;
- Each of the wind-run data sets had more than twenty percent missing data;
- Four of the sites had less than one year's data.

The data and reports are available at the Wind Resources Assessment Laboratory, Oregon State University.

Western Area Power Administration

The Western Area Power Administration initiated a Wind Prospecting Program in 1981. Six sites in the program were located in Montana, mostly in the eastern part of the state. Because the data were only available in hard copy, the sites were included in Appendix C and not in the main text of the *Atlas*. Four of the sites appeared to have substantial wind resources.

Private Companies

Many private companies have conducted their own wind monitoring programs in Montana. Most of these programs have been initiated to comply with air quality permit requirements. The scope of these efforts ranges from one year of monitoring at a single anemometer height to several years of monitoring at different anemometer heights. An example of the latter program is Montana Power Company's Salem site, where wind monitoring at three levels on a 100-meter tower ran from May 1980 to March 1984.

The advantages of the data gathered by these various private companies are:

- The anemometer heights are usually standardized;
- The data sets generally are complete and accurate;
- The data generally are available to the public in standard formats if submitted to fulfill permit requirements.

The disadvantages of these data are:

- Monitoring, in most cases, has taken place for only one year;
- The data may be confidential.

Other privately funded monitoring studies included the multi-site Northern Cheyenne Tribe-Montana Power Company monitoring system near Lame Deer, operated by GeoResearch, Inc., and the visibility monitoring site near Harlowton, operated for the Electric Power Research Institute (EPRI).

Conclusions

A large amount of wind data has been gathered in Montana over the last 30 years. The wind monitoring sites, however, generally have been concentrated in urban and other areas of low wind potential. In some areas of high wind potential, particularly along the eastern slopes of the Rockies, monitoring has been light. Winds in certain other promising areas, such as the upper Musselshell valley above Harlowton and the eastern slopes of the Little Belt Mountains from Utica to Geyser, also have not been adequately investigated. Considerable wind data, nonetheless, are available for areas of potential interest to wind developers.

When comparing wind data from sites where monitoring has been conducted, caution must be exercised. The monitoring objectives of the various programs have differed from agency to agency and often from project to project. As a result, other aspects of the monitoring programs also have differed.

Collection methods and averaging times have varied and anemometer heights have not been standardized, even within studies. The most serious problem with comparability of the data, in fact, is the difference in anemometer heights. Ten meters has now become the standard exposure height for most purposes, but some agencies, particularly the NWS and FAA, are still using an anemometer height of approximately 6 meters. A discussion of collection methods and averaging times is given in the site analysis for each station included in the *Atlas,* and the anemometer height is listed in the site's wind speed frequency table.

Quality assurance activities also have been inadequate in some cases, particularly for wind direction monitoring, occasionally leading to serious questions concerning the data. Wind direction data, however, are not as critical to wind energy analyses as wind speed data, which by and large appear to be valid or within a range of reasonable values.

The period of record, the number of observations, and the percentage of data recovery also have varied. Most monitoring efforts have been short term, lasting for three years or less. Many of these projects, moreover, were not conducted during the same years. The number of observations and data completeness also are a concern with some of the data sets, particularly where missing observations or data are not distributed uniformly among the months. Sites where monitoring took place for less than one year's duration, or with long periods or large amounts of missing data, generally have not been included in the *Atlas*.

Therefore, although caution must be exercised in comparing the wind data gathered at the various stations around Montana, the data presented and analyzed in this *Atlas* have been screened to form a basis for site evaluations and comparisons that will be within acceptable and reasonable statistical limits (see Appendix B).

Wind Energy Potential

The average distribution of wind movements over the entire earth is called the general circulation. The primary features of this circulation are the equatorial belt of low pressure (the doldrums); the subtropical high pressure belts (the horse latitudes); the polar low pressure; and the polar caps of high pressure.

Winds blowing out of the poleward side of the subtropical high pressure belts are deflected toward the east as they move into higher latitudes. These winds, which extend from about 35 to 60 degrees (north and south) latitude, are known as the prevailing westerlies. These winds blow throughout the year, but are strongest in winter.

Montana is located in the zone of prevailing westerlies, and it is these winds, modified primarily by near-surface effects such as friction and turbulence, that provide the wind resource in the state.

Air, like all other substances, has inertia; force is required to set it in motion. The major factors that drive the circulation of air are:

- Insolation: Energy from the sun heats the air unequally, mainly because the surfaces with which the air comes into contact heat at different rates;
- Gravitation: Unequal heating of the air produces differences in its density, and gravity causes the cooler, heavier air to sink;
- Condensation: Latent heat released by condensation of water vapor supplies a large amount of energy;
- Rotation: The earth's rotation changes the direction of air movement and produces the eastward and westward motions of air in the atmosphere.

The interaction of these major air circulation factors creates more specific forces, the balance of which determines the motion of air in a given area:

- Pressure gradient force: This force drives air from areas of high pressure to areas of low pressure;
- Coriolis force: This force, due to the rotation of the earth, deflects air to the right in the northern hemisphere;
- Centripetal force: This force arises when the air is moving in a curved, rather than straight, path along the earth's surface;
- Frictional forces: These forces include friction between the atmosphere and the earth's surface, as well as internal friction within the atmosphere.

Frictional forces are most important near the earth's surface and are the determining factors of the wind climatology at a specific location. Surface features associated with high wind speeds are mountain passes, high-elevation plateaus, long valleys extending down from mountain ranges, mountain ridges and summits, and the leeward slopes of mountain ranges perpendicular to the prevailing winds. Features associated with low average wind speeds include sheltered basins, valleys perpendicular to prevailing winds, and areas of high surface roughness.

There are four distinct wind provinces in Montana: western valley floors, eastern slopes, east and northeast plains, and exposed mountain crests. A discussion of each of these wind provinces follows.

Western Valley Floors

Most of the western third of Montana is mountainous. The region is crossed by many parallel mountain ranges with deep valleys between them. These valleys include: the Flathead, Bitterroot, and Deer Lodge valleys in western Montana; the upper Missouri River, Shields River, and Smith River valleys in the west-central portion of the state; and the Big Hole and Jefferson River valleys in southwestern Montana.

These valleys generally trend north-south or northwest-southeast and, thus, are oriented perpendicular to the prevailing wind direction. Because of their orientation, depth, and nar-

rowness, average wind speeds in these valleys are low. Periods of air stagnation, during which there is virtually no air movement, are common in these valleys, particularly in the autumn and winter. Certain limited areas in these valleys, such as the Kalispell-Columbia Falls area and the Hellgate Canyon just east of Missoula, occasionally experience high winds due to channeling through mountain gaps. Such occurrences, however, are comparatively rare.

Representative wind monitoring sites in the western valleys include the Missoula Hoerner-Waldorf site, the Ronan Nine Pipes site, and the Kalispell Airport site. Average annual wind speeds in these areas typically range from 5 to 10 miles per hour. Average annual wind power density generally ranges from 20 to 80 watts per square meter (watts/m^2).

Eastern Slopes

Air flowing over the Rocky Mountains is compressed and accelerated as it descends the eastern slopes of these mountains. When a strong pressure gradient exists, as it frequently does, these winds can become very high. The winds are strongest when channeled through east-west trending valleys.

Downslope areas are found along the eastern front of mountain ranges adjacent to broad valleys, such as in the Anaconda area and in the lower Jefferson River valley near Whitehall, as well as along the entire Rocky Mountain Front where the mountains meet the plains. This wind province actually extends well out into the plains, covering much of central Montana.

Areas where channeling of the winds by east-west mountain valleys results in stronger winds include the upper Yellowstone River valley from Livingston to Big Timber, the Browning-East Glacier-Cut Bank area, the upper Musselshell River valley around Harlowton and Judith Gap, the Jefferson River valley around Whitehall, and the Missouri River valley from Cascade to Great Falls.

Representative wind monitoring sites are the Livingston Candidate Wind Turbine site, the Bureau of Reclamation's Judith Gap and Cut Bank sites, and the Whitehall Airport site. These areas show pronounced seasonal variations in wind speed and wind power density. Highest average seasonal wind speeds occur during the winter and are generally from 12 to 25 miles per hour. Lowest average seasonal wind speeds, mostly from 8 to 12 miles per hour, occur during the summer. Average annual wind speeds are generally from 10 to 16 miles per hour. Average seasonal wind power ranges from between 600 and 2,000 watts/m^2 in winter to between 100 and 500 watts/m^2 in summer. Average annual wind power density is generally between 150 and 500 watts/m^2. Other representative sites include Yellowtail and Gibson dams, with average annual wind speeds in excess of 12 miles per hour.

Prevailing winds in these areas are generally from the southwest through west. Highest average wind speeds, likewise, are from these directions. At a given location, however, the orientation of nearby mountains may have a marked effect on the prevailing wind direction and speed.

East and Northeast Plains

The eastern slopes of the mountains give way to the east and northeast plains, which roughly occupy the corner of the state east of a Malta-Baker line. Because of the low surface roughness and low to moderate relief in this area, wind movement is dominated by pressure gradient forces. Prevailing wind directions are northwest and southeast.

Representative wind monitoring sites in this area include the Scobey Hanrahan site, the Glendive Microwave site, and the Glasgow Airport site. Average seasonal wind speeds are highest in the spring, when they are generally from 12 to 16 miles per hour. Lowest average seasonal wind speeds, between 4 and 10 miles per hour, occur in the autumn. Average annual wind speed is generally from 10 to 13 miles per hour. Average seasonal wind power density varies from about 50 to 150 watts/m^2 in autumn to between 100 and 300 watts/m^2 in the spring.

Exposed Mountain Crests

High, exposed mountain ranges and summits intercept the prevailing air flow. Air moving over a mountain range is compressed and accelerated as it passes over the crest. These effects are variable and depend on the orientation of the mountains with respect to the prevailing wind direction, the slope and elevation of the range, and the location and height of other nearby mountains.

All mountain ranges in Montana have exposed ridges and crests where average wind speed and power are likely to be high. Unfortunately, data from these areas are sparse. The most extensive data set available is the National Fire Weather

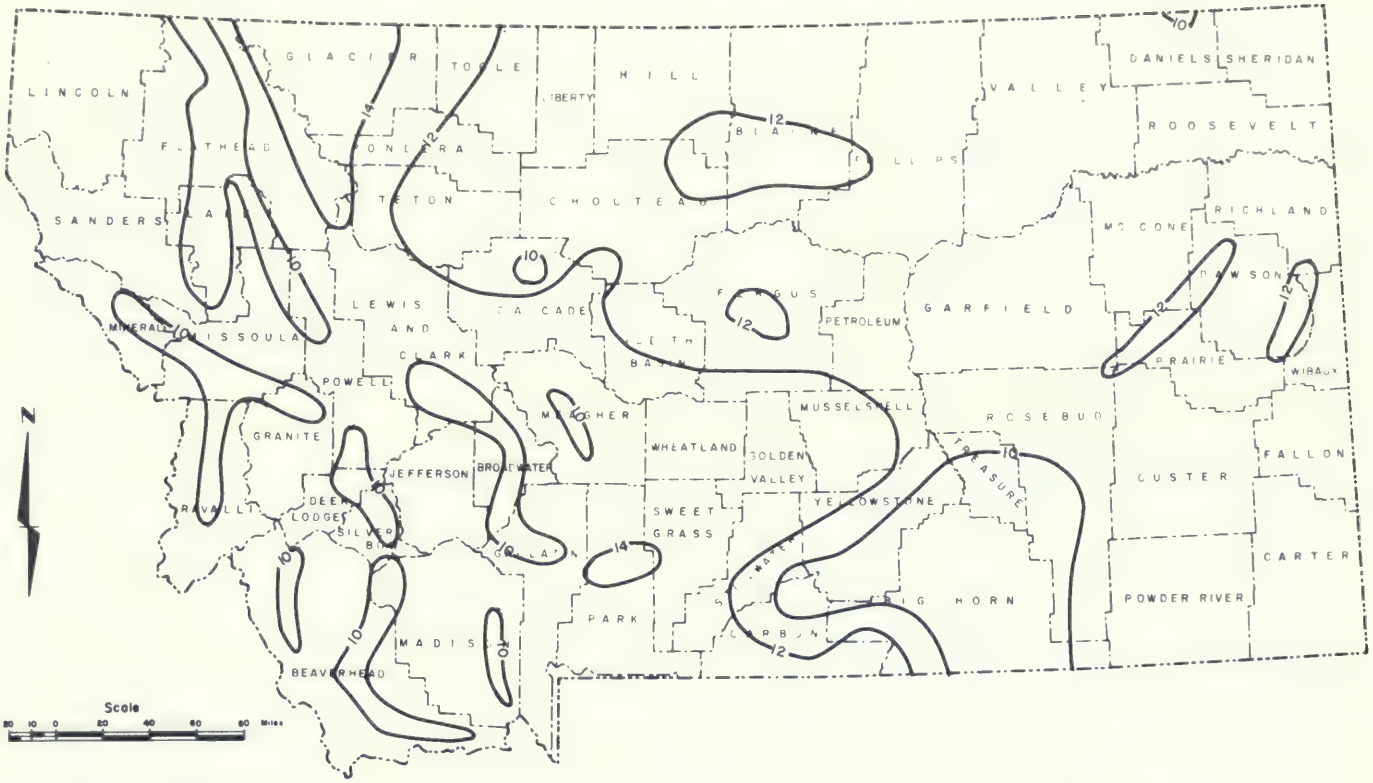
Data Library, maintained by the U.S. Forest Service. These data, however, were collected only one to three times daily, and only during the fire season. Nevertheless, the data have been analyzed by Battelle Pacific Northwest Laboratories and indicate average wind power densities ranging from 200 to more than 500 watts/m^2 for sites in western Montana.

Aerial surveys of tree deformation caused by winds also provide information on the wind resource at exposed mountain crests. Several indices of tree deformation, such as the Griggs-Putnam Index and the Barsch Index, have been developed to show a qualitative relationship between average annual wind speed and tree deformation. Researchers from Oregon State University in May 1981 conducted aerial surveys of most of western Montana for the Bonneville Power Administration. These surveys indicated average annual wind speeds of 14 to 20 miles per hour on most exposed ridges.

Summary

In summary, Montana may be divided into four general wind provinces: the western valleys, the eastern slopes, the east and northeast plains, and the exposed mountain crests. Maps III-1 and III-2 present generalized isopleths of average annual wind speed and wind power density in Montana. Given the state's sizable territory and the consequently low density of wind data available for the state, isopleth lines cannot be drawn with a high degree of precision. In a few instances, given areas with low data density and complex terrain, isopleths cannot be inferred at all. These maps, however, do provide a good picture, from a statewide perspective, of the relative wind potential of different parts of the state.

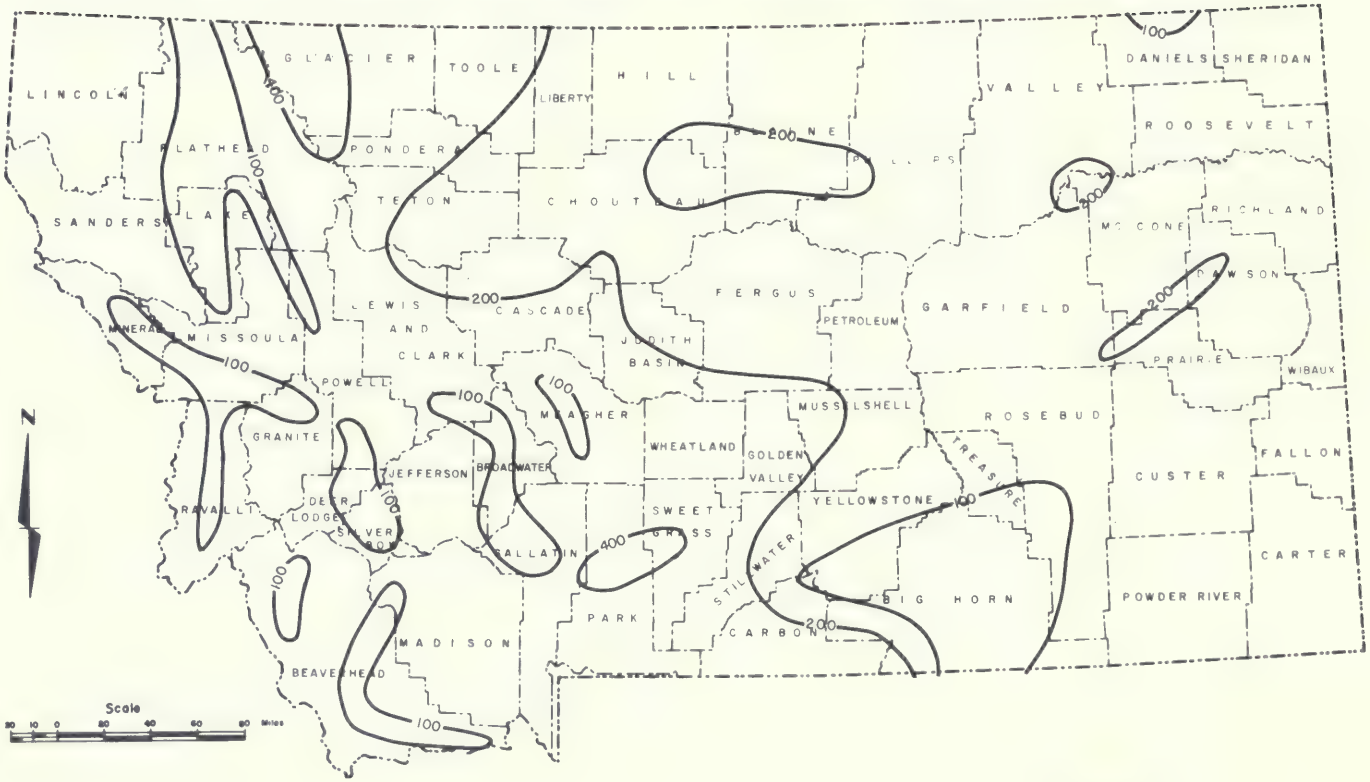
Map III-1. Generalized Annual Average Wind Speed Isopleths (Miles Per Hour)



Prepared By:

Geo Research Inc.

Map III-2. Generalized Annual Average Wind Power Isopleths (Watts Per Square Meter)



Prepared By:

Geo Research Inc.

Site-by-Site Wind Analyses

Wind data have been gathered at numerous sites in Montana through the years. Many of these sites were analyzed for the *Montana Wind Energy Atlas,* and the results for fifty-six of the sites are presented here. Other sites identified during this study are discussed briefly in Appendix C.

The site-by-site analyses are presented alphabetically by county and site name. This order is reflected in Table IV-1, which shows annual average wind speed (in miles per hour [mph] and meters per second [m/s]) and wind power (in watts per square meter [watts/m^2]) at anemometer height for each

Table IV-1
Sites Analyzed for the Montana Wind Energy Atlas
Annual Average Wind Speed and Wind Power

County	Site	Wind Speed (mph)	Wind Speed (m/s)	Wind Power (watts/m^2)
Beaverhead	Dillon FAA Airport*	9.2	4.1	80.0
Big Horn	Decker Coal #8	9.4	4.2	106.0
	Spring Creek #1	7.3	3.2	56.7
	Westmoreland Absaloka #2	6.3	2.8	25.8
Blaine	Hays	12.0	5.3	194.6
Broadwater	Three Forks	8.6	3.8	72.5
Cascade	Great Falls Malmstrom Air Force Base*	8.7	3.9	106.0
	GREAT FALLS NWS AIRPORT*	11.9	5.3	183.0
	Salem	10.2	4.6	139.7
Chouteau	Highwood Bench	10.5	4.7	122.6
Custer	Miles City FAA Airport*	10.5	4.7	116.0
Daniels	Scobey Border*	7.2	3.2	85.3
	SCOBEY HANRAHAN	11.6	5.2	178.3
Dawson	GLENDIVE MICROWAVE*	12.2	5.4	168.5

Table IV-1
Sites Analyzed for the Montana Wind Energy Atlas (cont'd.)
Annual Average Wind Speed and Wind Power

County	Site	Wind Speed (mph)	Wind Speed (m/s)	Wind Power (watts/m²)
Deer Lodge	ANACONDA C-HILL	13.3	6.0	279.8
	Anaconda Highway Junction	8.0	3.6	62.8
	Anaconda Mill Creek	9.5	4.2	95.2
	ANACONDA WEATHER HILL	17.0	7.6	517.4
Fergus	Lewistown FAA Airport*	10.1	4.5	109.0
Flathead	Big Prairie	3.4	1.5	8.4
	Columbia Falls Water Supply	6.4	2.9	48.3
	Kalispell NWS Airport*	6.9	3.1	53.0
Gallatin	Bozeman FAA Airport*	7.8	3.5	71.0
Glacier	Blackfoot*	16.4	7.3	432.3
	CUT BANK	12.8	5.7	217.1
	CUT BANK FAA AIRPORT*	12.5	5.6	228.0
Granite	Drummond FAA Airport*	7.2	3.2	52.0
Hill	Havre NWS Airport*	10.7	4.8	135.0
Jefferson	Microwave Tower*	10.8	4.8	237.6
	WHITEHALL FAA AIRPORT*	13.2	5.9	325.0
Lake	Ronan Ninepipes	4.5	2.0	17.0
Lewis & Clark	Helena NWS Airport*	7.8	3.5	69.0
	Sieben 1*	16.7	7.4	404.3
Liberty	Whitlash	13.6	6.1	259.6
Madison	Norris Hill	17.0	7.6	414.3
Mineral	Superior NWS Airport*	5.1	2.3	16.0
Missoula	Missoula Hoerner-Waldorf #1	5.1	2.3	30.5
	Missoula NWS Airport*	6.3	2.8	43.0
	Missoula University of Montana	6.3	2.8	48.8
Park	LIVINGSTON CANDIDATE WIND TURBINE SITE*	15.6	7.0	494.4
	LIVINGSTON FAA AIRPORT*	15.7	7.0	510.0
Pondera	Heart Butte*	18.0	8.0	649.7
Powder River	Broadus Randall Ranch*	10.1	4.5	118.9
Rosebud	COLSTRIP BN*	12.9	5.8	453.6
	Western Energy #12	7.3	3.3	48.4

Table IV-1
Sites Analyzed for the Montana Wind Energy Atlas (cont'd.)
Annual Average Wind Speed and Wind Power

County	Site	Wind Speed (mph)	Wind Speed (m/s)	Wind Power (watts/m²)
Silver Bow	Butte FAA Airport*	8.1	3.6	90.0
	Butte Hebgen Park	3.7	1.7	8.9
Teton	Choteau	10.1	4.5	116.0
Valley	Fort Peck*	10.6	4.7	219.9
	Glasgow Air Force Base*	9.6	4.3	109.0
	GLASGOW NWS AIRPORT*	11.0	4.9	139.0
Wheatland	JUDITH GAP	13.0	5.8	239.2
Yellowstone	BILLINGS NWS AIRPORT*	11.4	5.1	130.0
	Custer FAA Airport*	8.7	3.9	79.0
	Laurel New Farm	7.8	3.5	63.6
	Shawnee Park*	5.9	2.6	28.2

NOTE: Capitalized site names indicate high-potential sites.
* Asterisk indicates those sites at which the anemometer height was other than 10 meters. Data on wind speed and power are as recorded at the anemometer height.

Table IV-2
Sites Analyzed for the Montana Wind Energy Atlas
Wind Energy Potential Ranking by Wind Speed

Site Name	Anemometer Height (m)	Annual Average Wind Speed (mph)
HEART BUTTE, Pondera County	11.0	18.0
ANACONDA WEATHER HILL, Deer Lodge County	10.0	17.0
NORRIS HILL, Madison County	10.0	17.0
SIEBEN 1, Lewis and Clark County	11.0	16.7
BLACKFOOT, Glacier County	9.0	16.4
LIVINGSTON FAA AIRPORT, Park County	17.4	15.7
LIVINGSTON CANDIDATE WIND TURBINE SITE, Park County	9.1	15.6
WHITLASH, Liberty County	10.0	13.6
ANACONDA C-HILL, Deer Lodge County	10.0	13.3
WHITEHALL FAA AIRPORT, Jefferson County	9.1	13.2
JUDITH GAP, Wheatland County	7.0	13.0
COLSTRIP BN, Rosebud County	4.0	12.9
CUT BANK, Glacier County	10.0	12.8
CUT BANK FAA AIRPORT, Glacier County	6.1	12.5

Table IV-2

Sites Analyzed for the Montana Wind Energy Atlas (cont'd.)

Wind Energy Potential Ranking by Wind Speed

Site Name	Anemometer Height (m)	Annual Average Wind Speed (mph)
GLENDIVE MICROWAVE, Dawson County	4.0	12.2
HAYS, Blaine County	10.0	12.0
GREAT FALLS NWS AIRPORT, Cascade County	6.7	11.9
SCOBEY HANRAHAN, Daniels County	10.0	11.6
BILLINGS NWS AIRPORT, Yellowstone County	7.6	11.4
GLASGOW NWS AIRPORT, Valley County	6.1	11.0
Microwave Tower, Jefferson County	4.0	10.8
Havre NWS Airport, Hill County	6.1	10.7
Fort Peck, Valley County	4.0	10.6
Highwood Bench, Chouteau County	10.0	10.5
Miles City FAA Airport, Custer County	12.2	10.5
Salem, Cascade County	10.0	10.2
Choteau, Teton County	10.0	10.1
Lewistown FAA Airport, Fergus County	6.1	10.1
Broadus Randall Ranch, Powder River County	4.0	10.1
Glasgow Air Force Base, Valley County	4.0	9.6
Anaconda Mill Creek, Deer Lodge County	10.0	9.5
Decker Coal #8, Big Horn County	10.0	9.4
Dillon FAA Airport, Beaverhead County	6.1	9.2
Great Falls Malmstrom Air Force Base, Cascade County	4.6	8.7
Custer FAA Airport, Yellowstone County	10.1	8.7
Three Forks, Broadwater County	10.0	8.6
Butte FAA Airport, Silver Bow County	18.0	8.1
Anaconda Highway Junction, Deer Lodge County	10.0	8.0
Bozeman FAA Airport, Gallatin County	13.1	7.8
Helena NWS Airport, Lewis & Clark County	6.1	7.8
Laurel New Farm, Yellowstone County	10.0	7.8
Spring Creek #1, Big Horn County	10.0	7.3
Western Energy #12, Rosebud County	10.0	7.3
Drummond FAA Airport, Granite County	8.5	7.2

Table IV-2
Sites Analyzed for the Montana Wind Energy Atlas (cont'd.)
Wind Energy Potential Ranking by Wind Speed

Site Name	Anemometer Height (m)	Annual Average Wind Speed (mph)
Scobey Border, Daniels County	4.0	7.2
Kalispell NWS Airport, Flathead County	6.1	6.9
Columbia Falls Water Supply, Flathead County	10.0	6.4
Missoula NWS Airport, Missoula County	6.1	6.3
Missoula University of Montana, Missoula County	10.0	6.3
Westmoreland Absaloka #2, Big Horn County	10.0	6.3
Shawnee Park, Yellowstone County	4.0	5.9
Missoula Hoerner-Waldorf #1, Missoula County	10.0	5.1
Superior NWS Airport, Mineral County	17.7	5.1
Ronan Ninepipes, Lake County	10.0	4.5
Butte Hebgen Park, Silver Bow County	10.0	3.7
Big Prairie, Flathead County	10.0	3.4

NOTE: Capitalized site names indicate high-potential sites.
The rankings would have been different had all anemometers been at a standard height.

site analyzed. Table IV-2 ranks the sites according to their wind energy potential. Caution should be exercised in comparing the average speeds at sites with anemometers of different heights. (Readers wishing to determine the wind speed at a standard height of 10 meters may use the power law, discussed in Chapter V.)

Each site analysis includes a discussion of the time period of data collection, the method of data collection, and the quality of the data. Suspect data have been noted or deleted where possible; however, the quality of the data by and large reflects the quality assurance programs of the agencies that did the original data collection. Data summaries of monthly and annual average wind speed and wind power are provided. Monthly and annual wind speed distributions, showing the percentage of time the wind speed was within a given range, also are presented.

Sites where the average annual wind speed is equal to or greater than 11 miles per hour (4.9 meters per second) are considered "high potential" for purposes of this *Atlas*. For those sites with high wind energy potential, the following data summaries also are provided:

- Diurnal wind speed frequency distributions by season;
- Directional frequency and average wind speed (including wind rose graphics).

In addition, detailed descriptions of site characteristics are presented for the high-potential sites. These descriptions generally include information on current use of the site, availability of space for further development, ease of access, and distance from transmission lines, sensitive communications facilities, and aircraft corridors.

A table showing monthly and annual Weibull distribution coefficients (scale factor "c" and shape factor "k") also is presented for each of the high-potential sites. The two-parameter Weibull distribution has been found to be a reliable mathematical approximation of actual wind speed distributions for many locations and is widely used for wind modeling purposes. (The Weibull distribution is discussed in Appendix B.)

DILLON FAA AIRPORT

BEAVERHEAD COUNTY

The Dillon airport is located approximately 5 miles northeast of Dillon at 45 15 00 N and 112 33 00 W (Site No. 1 on Map II-1). Elevation at the airport is 5,223 feet. Meteorological data were collected here for many years by the Federal Aviation Administration.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the data set was split into two parts for analysis: June 19, 1951, through October 29, 1963; and October 30, 1963, through June 18, 1973. Data from the latter period only were selected for inclusion in the *Montana Wind Energy Atlas.*

The data set for Dillon consists of summaries of observations made every third hour from October 30, 1963, through June 18, 1973. The anemometer was mounted on a ground mast at a height of 6.1 meters. The site is representative of the Jefferson River Valley from Twin Bridges to south of Dillon.

Average monthly wind speed varied from 7.6 miles per hour in July and August to 10.5 miles per hour in January. Average annual wind speed was 9.2 miles per hour.

Average monthly wind power ranged from 43.0 watts/m^2 in August to 114.0 watts/m^2 in January. Average annual wind power was 80.0 watts/m^2.

Table IV - 3

Monthly Wind Speed Distribution

BEAVERHEAD COUNTY - DILLON FAA AIRPORT

10/30/63 - 06/18/73

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	5.6	7.0	5.7	5.7	5.7	8.5	8.8	7.5	6.7	7.1	8.3	7.9	7.0	CALM (<0.5)
1.1- 3.1	0.6	0.7	0.7	0.8	0.8	0.8	1.2	0.8	1.0	0.8	0.8	0.7	0.8	0.5- 1.4
3.4- 5.4	9.7	9.6	12.1	11.7	14.2	13.8	16.8	16.1	14.4	12.9	13.2	12.0	13.0	1.5- 2.4 S
S 5.6- 7.6	16.1	19.9	18.9	19.2	22.5	24.7	30.0	30.4	24.0	22.7	22.0	20.7	22.5	2.5- 3.4 P
P 7.8- 9.8	20.0	19.8	17.6	19.1	20.1	21.8	22.4	24.1	23.5	23.0	22.7	19.0	21.0	3.5- 4.4 E
E 10.1-12.1	14.6	15.4	13.8	12.2	12.0	10.4	8.4	10.3	12.7	13.7	12.2	13.9	12.5	4.5- 5.4 E
E 12.3-14.3	8.6	8.2	8.6	7.7	7.1	7.1	4.3	3.8	5.6	5.5	6.1	7.9	6.8	5.5- 6.4 D
D 14.5-16.6	6.8	5.5	6.6	5.5	4.4	4.3	2.4	2.6	3.4	3.6	4.2	6.0	4.7	6.5- 7.4
16.8-18.8	9.2	7.5	8.4	8.0	6.6	5.4	2.9	2.5	4.4	4.7	6.1	6.3	6.0	7.5- 8.4 M
M 19.0-21.0	4.3	2.8	3.7	3.7	2.8	1.5	1.2	0.7	1.9	3.1	2.2	2.8	2.6	8.5- 9.4 E
I 21.3-23.3	3.3	2.6	3.1	5.0	2.6	1.5	1.1	0.9	1.8	2.3	1.7	2.1	2.3	9.5-10.4 T
L 23.5-25.5	0.5	0.6	0.3	0.7	0.3	0.0	0.2	0.1	0.2	0.2	0.2	0.5	0.3	10.5-11.4 E
E 25.7-27.7	0.2	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.2	0.1	0.1	0.0	0.1	11.5-12.4 R
S 28.0-30.0	0.4	0.4	0.5	0.5	0.4	0.1	0.3	0.1	0.3	0.1	0.1	0.4	0.3	12.5-13.4 S
/ 30.2-32.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	13.5-14.4 /
H 32.4-34.4	0.0	0.0	0.0	0 1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	14.5-15.4 S
O 34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	10.5	9.8	10.1	10.3	9.4	8.5	7.6	7.6	8.5	8.9	8.7	9.4	9.2	
AVERAGE SPEED (M/SEC)	4.7	4.4	4.5	4.6	4.2	3.8	3.4	3.4	3.8	4.0	3.9	4.2	4.1	
AVERAGE WIND POWER (WATTS/M**2)	114.0	92.0	101.0	112.0	83.0	60.0	48.0	43.0	67.0	73.0	70.0	85.0	80.0	

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

DECKER COAL #8

BIG HORN COUNTY

The Decker Coal #8 air monitoring site is located approximately 4 miles northeast of Decker at 45 03 19 N and 106 48 17 W (Site No. 2 on Map II-1). Elevation at the site is 3,480 feet. The site was established by Decker Coal Company to monitor concentrations of particulates in the air around the mine.

Wind parameters have been monitored long enough to give a good picture of the wind resource in the area. Wind data from December 1, 1980, through May 31, 1982, were available for analysis. The data set consists of hourly averages of wind speed and wind direction, manually reduced from stripchart records, at an anemometer height of 10 meters. Data recovery was excellent, ranging from 85.5 percent in January to 100.0 percent in February, September, and October. Overall data recovery was 95.9 percent.

Average annual wind speed at this site was 9.4 miles per hour. Monthly wind speeds varied from 6.6 miles per hour in August to 11.8 miles per hour in May.

Average annual wind power was 106.0 watts/m^2. Monthly average wind power ranged from 37.0 watts/m^2 in September to 161.4 watts/m^2 in May.

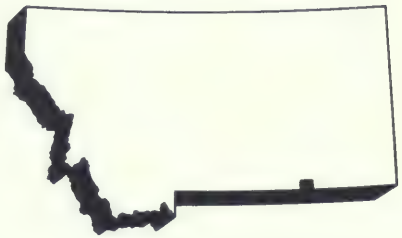


Table IV - 4

Monthly Wind Speed Distribution

BIG HORN COUNTY - DECKER COAL #8

12/01/80 - 05/31/82

WIND SPEED (KNOTS)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	WIND SPEED (M/SEC)
CALM	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1- 0.4
1.1-2.0	0.0	0.5	0.0	0.0	0.0	0.0	0.7	0.3	0.0	0.0	0.0	0.0	0.1	0.5- 0.9
2.1-3.0	0.2	0.1	0.2	0.0	0.1	0.2	0.5	1.0	0.8	0.0	0.0	0.0	0.2	1.0- 1.3
3.1-4.0	4.7	3.0	3.2	1.0	0.8	4.0	5.9	12.0	9.9	0.4	0.3	0.2	3.2	1.4- 1.8
4.1-5.0	14.5	11.5	9.7	4.8	5.0	13.1	21.4	37.8	38.6	7.0	8.4	20.5	14.4	1.9- 2.2
5.1-6.0	13.1	20.4	14.1	10.6	8.4	10.0	9.2	12.8	14.3	32.4	30.8	11.3	14.7	2.3- 2.7
6.1-7.0	13.3	13.0	8.6	10.2	9.8	6.1	6.2	5.1	4.3	12.6	31.0	17.5	11.6	2.8- 3.1
7.1-8.0	8.6	9.1	7.6	9.1	9.1	7.4	7.7	4.9	3.6	8.7	7.7	9.9	8.1	3.2- 3.6
8.1-9.0	5.6	6.1	6.6	7.8	8.9	4.9	7.3	3.3	4.0	6.9	2.5	8.7	6.5	3.7- 4.0
9.1-10.0	4.6	6.3	6.6	6.0	6.7	7.8	5.7	2.4	2.1	4.2	1.9	6.3	5.4	4.1- 4.5
10.1-11.0	3.9	4.9	5.1	6.2	6.5	7.5	5.8	3.2	2.6	3.8	1.5	4.3	4.8	4.6- 4.9
11.1-12.0	4.6	3.1	4.5	4.1	3.2	5.1	5.0	2.9	2.6	3.1	1.2	2.8	3.6	5.0- 5.4
12.1-13.0	3.8	2.7	4.3	4.0	4.0	3.7	5.4	2.2	2.9	2.4	1.3	2.9	3.4	5.5- 5.8
13.1-14.0	3.2	2.1	3.5	3.0	5.0	3.4	3.6	1.5	2.1	2.6	1.6	1.8	2.9	5.9- 6.3
14.1-15.0	2.7	2.2	3.0	4.2	4.4	2.8	3.0	2.1	2.4	3.0	1.3	2.1	2.9	6.4- 6.7
15.1-16.0	2.4	1.9	2.6	3.6	3.2	2.6	2.4	2.2	2.5	2.0	1.2	1.8	2.4	6.8- 7.2
16.1-17.0	2.8	1.6	2.7	2.9	2.9	3.2	2.0	1.0	2.4	1.7	1.3	2.2	2.3	7.3- 7.6
17.1-18.0	1.7	1.5	2.3	2.6	3.2	2.0	1.9	0.8	1.9	1.7	0.7	1.1	1.9	7.7- 8.0
18.1-19.0	1.0	1.3	2.1	3.5	2.7	2.2	1.3	1.3	0.6	1.9	1.2	1.3	1.8	8.1- 8.5
19.1-20.0	0.9	1.4	1.4	3.1	2.2	1.5	0.4	0.6	1.3	0.7	1.3	0.5	1.4	8.6- 8.9
20.1-25.0	5.7	4.5	8.3	9.7	9.3	7.1	3.4	1.9	1.1	4.0	3.8	2.6	5.6	9,0-11.2
25.1-30.0	1.3	1.4	1.9	2.6	3.4	3.2	0.7	0.4	0.0	0.8	1.2	0.9	1.6	11.3-13.4
30.1-35.0	1.1	0.8	1.2	0.8	1.2	1.7	0.4	0.1	0.0	0.1	0.0	0.9	0.8	13.5-15.6
35.1-40.0	0.2	0.2	0.2	0.2	0.1	0.5	0.0	0.1	0.0	0.0	0.0	0.3	0.2	15.7-17.9
>40.0	0.1	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.1	>17.9
AVERAGE SPEED (MPH)	9.3	8.8	10.5	11.6	11.8	10.9	8.6	6.6	6.7	8.4	7.6	8.4	9.4	
AVERAGE SPEED (M/SEC)	4.2	3.9	4.7	5.2	5.3	4.9	3.8	3.0	3.0	3.8	3.4	3.8	4.2	
AVERAGE WIND POWER (WATTS/M**2)	114.0	96.2	135.6	158.3	161.4	157.0	70.8	42.9	37.0	65.9	58.0	88.8	106.0	
PERCENT DATA RECOVERY	85.5	100.0	97.2	99.9	95.8	90.4	99.9	96.6	100.0	100.0	95.6	93.3	95.9	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 12589
PERCENTAGE DATA RECOVERY = 95.9

SOURCE: GEORESEARCH, INC.

SPRING CREEK #1

BIG HORN COUNTY

The Spring Creek #1 air monitoring site is located approximately 7 miles north of Decker at 45 07 02 N and 106 52 32 W (Site No. 5 on Map II-1). Elevation at the site is 3,838 feet. Wind data have been gathered at the Spring Creek Coal Company mine site since January 1, 1981. Data through December 31, 1981, were available for analysis.

The data set contains hourly averages for wind speed and wind direction at an anemometer height of 10 meters. Data recovery for the year was 90.9 percent and was greater than 80.0 percent during all months except November. Although the monitoring period was short, it was adequate to provide a good indication of the wind resource at this location.

Average annual wind speed was 7.3 miles per hour. Monthly average wind speeds were from 4.5 miles per hour in January to 9.9 miles per hour in May. April through June and September through October were the windiest months at this site.

Average monthly wind power ranged from 26.4 watts/m^2 in January to 107.1 watts/m^2 in May. Annual average wind power was 56.7 watts/m^2.

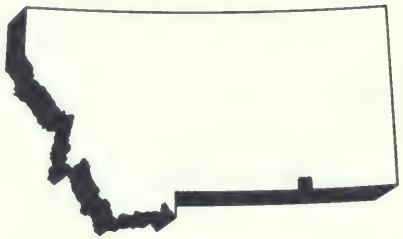


Table IV - 5

Monthly Wind Speed Distribution

BIG HORN COUNTY - SPRING CREEK #1

01/01/81 - 12/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	18.8	7.9	8.1	2.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	5.5	3.9	0.1- 0.4
1.1-2.0	21.7	18.5	13.6	9.5	2.0	0.2	0.3	0.8	2.5	1.9	6.4	5.7	6.9	0.5- 0.9
2.1-3.0	11.4	13.0	9.8	8.0	4.4	2.5	3.8	7.8	9.1	7.6	20.8	18.9	9.2	1.0- 1.3
3.1-4.0	8.8	6.7	10.7	7.6	6.8	8.3	10.4	14.0	9.2	15.7	14.4	17.6	10.7	1.4- 1.8
4.1-5.0	5.9	5.1	10.7	10.2	7.6	9.4	11.2	11.9	11.1	16.3	9.6	9.6	10.0	1.9- 2.2
5.1-6.0	6.9	4.8	7.1	6.9	9.1	12.2	11.2	14.2	11.6	12.1	6.1	8.8	9.4	2.3- 2.7
6.1-7.0	5.6	3.7	6.0	6.6	8.5	11.2	10.1	13.7	12.5	7.8	4.8	4.1	8.1	2.8- 3.1
7.1-8.0	2.7	3.4	4.9	6.8	8.0	7.7	10.4	8.5	8.5	6.1	4.2	5.8	6.6	3.2- 3.6
8.1-9.0	3.0	5.1	3.9	5.3	6.0	8.2	11.7	6.1	5.0	5.3	3.5	3.6	5.7	3.7- 4.0
9.1-10.0	2.6	4.8	3.0	4.7	6.3	6.0	8.8	4.4	5.3	3.1	5.8	3.6	4.8	4.1- 4.5
10.1-11.0	2.0	4.6	2.8	5.2	6.6	4.9	5.3	5.0	4.9	2.9	2.2	2.7	4.2	4.6- 4.9
11.1-12.0	1.4	3.1	3.0	3.6	5.0	4.0	5.5	3.1	3.6	2.9	3.8	2.5	3.5	5.0- 5.4
12.1-13.0	2.3	3.4	3.1	2.6	4.7	3.1	3.4	3.2	3.4	4.4	1.0	2.2	3.2	5.5- 5.8
13.1-14.0	1.9	2.5	2.2	3.7	4.4	4.3	2.6	2.7	2.8	3.8	2.2	1.3	2.9	5.9- 6.3
14.1-15.0	1.1	0.9	1.1	2.6	2.5	3.2	2.2	1.1	2.0	2.9	2.2	1.3	1.9	6.4- 6.7
15.1-16.0	1.0	1.3	1.4	2.4	2.7	2.5	0.7	0.7	3.1	1.6	1.6	0.8	1.6	6.8- 7.2
16.1-17.0	0.6	1.9	1.9	2.7	3.1	3.4	0.7	0.9	1.5	0.7	1.0	1.3	1.6	7.3- 7.6
17.1-18.0	0.9	1.3	2.2	1.7	1.6	1.5	0.3	0.7	1.3	1.9	1.0	0.3	1.2	7.7- 8.0
18.1-19.0	0.1	1.3	0.8	1.4	0.6	1.2	0.4	0.3	0.7	0.8	1.3	0.6	0.8	8.1- 8.5
19.1-20.0	0.3	1.5	0.8	2.0	0.9	0.8	0.4	0.1	0.8	0.7	1.6	0.6	0.8	8.6- 8.9
20.1-25.0	1.0	3.9	1.9	3.4	7.4	3.9	0.8	0.7	1.0	1.5	1.3	1.9	2.4	8.9-11.2
25.1-30.0	0.0	0.9	1.1	0.7	1.3	1.4	0.1	0.1	0.0	0.0	0.0	0.8	0.5	11.2-13.4
30.1-35.0	0.0	0.1	0.0	0.1	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.6	0.1	13.4-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	4.5	6.9	6.5	8.2	9.9	9.2	7.7	6.9	7.5	7.2	6.2	6.1	7.3	
AVERAGE SPEED (M/SEC)	2.0	3.1	2.9	3.7	4.4	4.1	3.4	3.1	3.4	3.2	2.8	2.7	3.2	
AVERAGE WIND POWER (WATTS/M**2)	26.4	73.4	57.3	78.3	107.1	84.2	38.7	32.5	45.1	45.7	41.8	54.1	56.7	
PERCENT DATA RECOVERY	93.5	99.7	99.1	96.7	85.3	90.1	99.7	99.7	99.2	98.7	43.5	85.5	90.9	

SPEED / MIDDLE / SPEED

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 7964
PERCENTAGE DATA RECOVERY = 90.9

SOURCE: GEORESEARCH, INC.

WESTMORELAND ABSALOKA #2

BIG HORN COUNTY

The Absaloka #2 air monitoring site is located approximately 30 miles east of Hardin at 45 46 27 N and 107 04 57 W (Site No. 6 on Map II-1). Elevation at the site is 3,539 feet. The site was established by Westmoreland Resources to monitor particulate concentrations in the air around the Absaloka mine.

Wind data have been gathered at this site since August 1, 1980. Data through March 29, 1982, were available for analysis. The data set contains hourly averages for wind speed and wind direction, which were reduced from stripchart records. Anemometer height was 10 meters. Data recovery was excellent, ranging from 96.9 percent in October to 100.0 percent during several months. Overall, 99.3 percent of the available data were recovered.

Average annual wind speed was 6.3 miles per hour. Monthly average wind speed ranged from 5.5 miles per hour in December to 7.8 miles per hour in April. The windiest months were April through June.

Average monthly wind power varied from 18.9 watts/m^2 in November to 43.2 watts/m^2 in April. Annual average wind power was 25.8 watts/m^2.

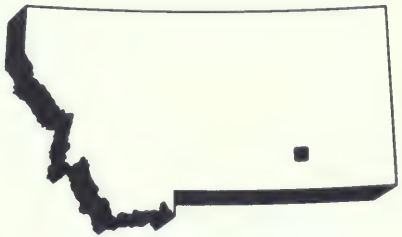


Table IV - 6

Monthly Wind Speed Distribution

BIG HORN COUNTY - WESTMORELAND ABSALOKA #2

08/01/80 - 03/29/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.0	0.1	0.4	0.0	0.5	0.0	0.9	0.7	0.4	0.0	0.0	0.9	0.3	0.1- 0.4
1.1-2.0	3.0	3.0	3.6	0.8	0.9	1.3	3.9	5.1	3.8	2.6	2.4	5.3	3.2	0.5- 0.9
S 2.1-3.0	11.0	8.8	10.9	6.5	6.1	5.0	8.6	9.0	7.9	9.2	8.8	13.9	9.3	1.0- 1.3
P 3.1-4.0	18.3	13.2	14.3	8.9	12.1	8.3	11.0	9.9	11.3	12.1	17.0	17.6	13.4	1.4- 1.8
E 4.1-5.0	18.6	15.3	12.1	11.4	12.4	11.4	12.8	11.3	12.0	14.8	19.7	16.0	14.4	1.9- 2.2
E 5.1-6.0	14.6	13.0	11.3	9.9	10.6	12.9	16.7	14.4	12.9	12.6	15.2	12.6	13.2	2.3- 2.7
D 6.1-7.0	10.5	12.6	10.7	11.9	10.8	13.2	11.3	13.0	10.9	12.8	12.1	7.5	11.4	2.8- 3.1
7.1-8.0	5.7	8.9	9.5	9.4	8.5	10.7	11.7	10.6	12.4	10.5	6.7	6.7	9.1	3.2- 3.6
M 8.1-9.0	5.7	6.3	8.1	6.9	6.2	10.3	7.4	7.6	7.8	6.4	6.1	5.1	6.8	3.7- 4.0
I 9.1-10.0	3.6	5.7	5.2	6.5	5.7	5.7	4.3	6.9	5.5	5.5	3.6	3.6	5.0	4.1- 4.5
L 10.1-11.0	1.7	3.8	3.6	7.1	7.3	6.4	4.7	4.0	4.1	4.4	2.6	3.4	4.0	4.6- 4.9
E 11.1-12.0	1.6	2.5	2.7	4.4	5.5	4.7	2.6	2.5	3.4	2.8	1.9	1.7	2.8	5.0- 5.4
S 12.1-13.0	1.3	2.1	2.1	5.7	3.4	3.5	1.6	2.3	3.1	1.5	1.0	1.6	2.2	5.5- 5.8
/ 13.1-14.0	1.2	1.8	2.4	2.8	3.2	1.8	1.2	0.9	1.5	1.5	0.9	1.2	1.6	5.9- 6.3
H 14.1-15.0	1.3	1.1	1.1	2.5	1.9	1.4	0.5	0.7	1.0	0.8	0.7	0.9	1.1	6.4- 6.7
O 15.1-16.0	0.3	0.7	0.7	1.4	1.2	1.0	0.3	0.2	0.7	1.0	0.2	0.7	0.6	6.8- 7.2
U 16.1-17.0	0.4	0.6	0.3	1.5	1.2	0.3	0.0	0.1	0.6	0.4	0.3	0.4	0.5	7.3- 7.6
R 17.1-18.0	0.3	0.2	0.2	1.0	0.7	0.7	0.1	0.3	0.3	0.2	0.1	0.3	0.3	7.7- 8.0
18.1-19.0	0.6	0.0	0.3	0.6	0.3	1.3	0.1	0.2	0.1	0.1	0.3	0.3	0.3	8.1- 8.5
19.1-20.0	0.1	0.1	0.1	0.6	0.5	0.3	0.1	0.1	0.2	0.1	0.1	0.1	0.2	8.6- 8.9
20.1-25.0	0.3	0.0	0.7	0.1	1.1	0.0	0.1	0.2	0.1	0.8	0.2	0.2	0.3	9,0-11.2
25.1-30.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	5.7	6.3	6.4	7.8	7.5	7.4	6.1	6.3	6.6	6.4	5.7	5.5	6.3	
AVERAGE SPEED (M/SEC)	2.6	2.8	2.8	3.5	3.4	3.3	2.7	2.8	2.9	2.9	2.6	2.5	2.8	
AVERAGE WIND POWER (WATTS/M**2)	23.2	24.3	28.4	43.2	41.1	34.2	19.9	21.9	25.8	26.9	18.9	20.9	25.8	
PERCENT DATA RECOVERY	100.0	100.0	99.1	100.0	99.9	100.0	100.0	97.9	99.2	96.9	99.7	100.0	99.3	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 14438
PERCENTAGE DATA RECOVERY = 99.3

SOURCE: GEORESEARCH, INC.

HAYS
BLAINE COUNTY

The Hays site is located seven miles north of Hays and about twenty-eight miles south of Fort Belknap at 48 06 17 N and 108 42 43 W (Site No. 150 on Map II-1). Elevation at the site is 3,150 feet. This monitoring site is part of the wind monitoring program of the Montana Department of Natural Resources and Conservation.

The site is on top of McGuire Hill in a rolling grassland area typical of eastern Montana. It has excellent exposure to winds from all directions. The site is typical of a series of low ridges (drainage divides) that run approximately northeast-southwest between the Little Rockies and Bears Paw Mountains. The site is right next to state Highway 66. Winter access is good.

The site is located on the Fort Belknap Reservation. Electrical service in the area is provided by the Big Flat Electric Cooperative. A 69 kV line runs next to the site and a 230 kV line, 28 miles to the north, runs between Fort Peck and Havre. There is no commercial airport nearby.

The site was installed December 14, 1983. Wind data were collected from January 1, 1984 to July 15, 1985. A Met One anemometer and a Campbell Scientific datalogger were used. The anemometer height was 33 feet.

Data recovery was poor to excellent, ranging from 31.3 percent in September to 100.0 percent in October. Overall data recovery was 87.5 percent.

Average monthly wind speeds ranged from 8.9 miles per hour in August to 13.9 miles per hour in December. Average annual wind speed was 12.0 miles per hour.

Average monthly wind power ranged from 72.5 watts/m^2 in August to 336.4 watts/m^2 in December.

Average wind speed did not vary much between seasons. Average seasonal speeds were 10.7 miles per hour in the summer, 11.4 miles per hour in the autumn, 13.0 miles per hour in the winter, and 12.0 miles per hour in the spring. In the winter and spring, the highest wind speed occurred in early afternoon. High winds in the summer were a little later than in the winter and spring, and high winds in the autumn were a little earlier. Diurnal range of average wind speeds was greatest in the summer and least in the winter.

Valid wind direction data were not collected between January 30, 1984 and July 20, 1984; the effect of this on the wind direction statistics is unknown. According to the available data, the wind blew most frequently from the south-southwest through the west-southwest. Winds were least common from the east-northeast through the south-southeast. By direction, average wind speeds ranged from 6.7 miles per hour from the south-southeast to 16.3 miles per hour from the northwest.

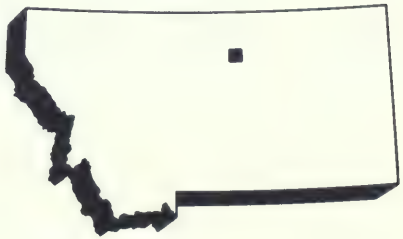


Table IV - 7

Monthly Wind Speed Distribution

BLAINE COUNTY - HAYS

01/01/84 - 07/15/85

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM	0.4	0.1	0.0	0.1	1.8	0.6	0.0	2.0	3.1	0.7	0.4	0.4	0.6	CALM	
0.1-1.0	1.0	1.2	0.3	0.1	0.3	0.5	0.2	0.4	0.0	0.8	0.8	1.6	0.6	0.1- 0.4	
1.1-2.0	3.0	1.9	1.6	0.9	0.8	0.7	0.9	0.4	4.0	2.3	1.2	1.9	1.5	0.5- 0.9	S
S 2.1-3.0	2.8	2.7	4.3	1.6	2.1	1.8	2.6	4.3	1.8	2.4	2.9	3.1	2.7	1.0- 1.3	P
P 3.1-4.0	4.7	5.1	6.8	4.0	4.7	5.6	4.3	7.8	5.3	5.8	4.5	4.7	5.2	1.4- 1.8	E
E 4.1-5.0	5.3	4.0	6.9	4.2	5.4	4.7	6.8	10.2	9.3	5.1	2.9	5.9	5.6	1.9- 2.2	E
E 5.1-6.0	5.3	5.8	7.7	7.5	7.6	7.4	9.9	8.2	12.4	8.7	7.0	7.7	7.5	2.3- 2.7	D
D 6.1-7.0	4.5	5.5	7.5	6.2	5.3	6.4	8.4	6.4	10.2	6.3	4.5	6.1	6.2	2.8- 3.1	
7.1-8.0	4.9	6.7	8.3	7.0	8.7	6.5	9.5	11.5	11.1	5.4	7.0	3.4	7.2	3.2- 3.6	M
M 8.1-9.0	5.5	6.1	6.3	5.6	5.8	6.4	8.2	8.2	4.4	4.3	6.2	3.9	6.0	3.7- 4.0	E
I 9.1-10.0	4.7	6.2	7.0	6.0	7.2	6.0	8.5	8.2	6.7	7.7	4.5	5.5	6.5	4.1- 4.5	T
L 10.1-11.0	3.2	4.4	4.3	4.0	5.1	6.6	5.6	4.3	2.2	6.5	4.1	2.0	4.5	4.6- 4.9	E
E 11.1-12.0	5.1	5.9	4.7	5.0	4.7	5.4	5.5	4.5	6.7	5.8	4.5	3.2	5.0	5.0- 5.4	R
S 12.1-13.0	4.2	4.3	3.8	3.7	4.1	4.9	3.8	3.5	1.8	4.7	2.9	2.8	3.9	5.5- 5.8	S
/ 13.1-14.0	5.0	5.2	4.6	5.1	5.3	4.2	3.9	6.6	2.2	5.0	4.5	4.0	4.8	5.9- 6.3	/
H 14.1-15.0	3.2	2.8	3.7	2.9	3.0	3.5	3.0	2.7	2.2	3.2	2.5	2.8	3.1	6.4- 6.7	S
O 15.1-16.0	3.4	4.2	3.3	2.8	2.6	3.4	2.1	2.7	2.7	2.6	1.7	2.8	3.0	6.8- 7.2	E
U 16.1-17.0	4.0	4.0	3.1	3.8	3.5	3.1	2.4	2.1	1.8	2.6	2.5	2.8	3.2	7.3- 7.6	C
R 17.1-18.0	3.3	3.0	3.4	2.9	2.2	2.4	2.6	1.4	1.8	2.6	1.7	3.2	2.7	7.7- 8.0	O
18.1-19.0	4.5	3.6	3.5	3.1	2.6	2.6	3.0	0.8	0.9	3.9	3.3	3.0	3.2	8.1- 8.5	N
19.1-20.0	2.5	2.3	2.5	2.7	2.0	2.5	1.8	0.2	1.3	2.4	3.3	3.4	2.3	8.6- 8.9	D
20.1-25.0	10.5	9.9	4.9	11.5	6.8	9.5	5.9	2.7	7.6	8.5	20.2	14.5	8.8	9.0-11.2	
25.1-30.0	5.6	3.5	1.4	5.9	4.5	3.9	0.7	0.4	0.0	2.2	4.1	6.3	3.6	11.3-13.4	
30.1-35.0	2.8	1.1	0.1	1.5	2.8	1.0	0.3	0.2	0.0	0.5	1.7	2.6	1.4	13.5-15.6	
35.1-40.0	0.6	0.4	0.1	1.3	0.7	0.2	0.1	0.0	0.4	0.3	0.8	1.3	0.5	15.7-17.9	
>40.0	0.3	0.2	0.0	0.6	0.4	0.1	0.0	0.2	0.0	0.0	0.0	0.9	0.2	>17.9	
AVERAGE SPEED (MPH)	13.2	12.3	10.4	13.5	12.2	12.1	10.3	8.9	9.2	11.3	13.7	13.9	12.0		
AVERAGE SPEED (M/SEC)	5.9	5.5	4.6	6.0	5.5	5.4	4.6	4.0	4.1	5.0	6.1	6.2	5.3		
AVERAGE WIND POWER (WATTS/M**2)	267.4	201.0	114.3	262.9	214.4	173.6	99.2	72.5	92.2	148.3	261.1	336.4	194.6		
PERCENT DATA RECOVERY	99.7	90.1	99.2	99.9	99.3	78.1	99.0	68.8	31.3	100.0	33.6	99.9	87.5		

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 11726
PERCENTAGE DATA RECOVERY = 87.5

SOURCE: GEORESEARCH, INC.

Table IV - 8

Percentage Frequency Summary for Wind Speed

BLAINE COUNTY - HAYS

(WINTER)

01/01/84 - 07/15/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (METERS/SECOND)																	
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	4.2	6.9	14.6	10.4	12.5	11.1	11.8	6.3	4.9	2.1	9.0	6.3	0.0	0.0	0.0	11.7	5.2
	2	0.0	4.2	9.0	13.2	11.8	12.5	9.0	9.0	4.9	5.6	4.9	13.2	2.8	0.0	0.0	0.0	11.6	5.2
	3	0.7	2.1	6.9	14.6	12.5	14.6	6.9	8.3	4.2	9.7	2.8	12.5	3.5	0.7	0.0	0.0	11.8	5.3
	4	0.0	2.8	10.4	9.7	13.9	13.2	7.6	6.3	4.9	7.6	4.9	13.2	4.2	1.4	0.0	0.0	12.2	5.4
	5	0.0	2.1	8.3	14.6	11.1	11.8	9.0	5.6	3.5	9.0	10.4	9.0	4.2	0.7	0.0	0.7	12.5	5.6
	6	0.0	2.1	8.3	11.1	14.6	11.1	6.9	6.9	6.9	6.9	8.3	12.5	2.1	1.4	0.0	0.7	12.7	5.7
	7	0.0	0.7	7.6	12.5	12.5	11.1	8.3	9.0	7.6	7.6	5.6	10.4	3.5	2.8	0.0	0.7	13.0	5.8
	8	0.0	4.2	6.3	6.9	11.8	16.0	8.3	9.0	8.3	6.9	4.9	10.4	3.5	2.8	0.0	0.7	13.0	5.8
H	9	0.0	6.3	5.6	8.3	8.3	13.9	12.5	10.4	3.5	5.6	4.2	15.3	2.8	2.8	0.0	0.7	13.0	5.8
	10	0.7	3.5	6.3	13.9	6.9	11.8	9.0	9.7	6.3	6.3	4.9	12.5	4.2	2.8	1.4	0.0	13.1	5.8
O	11	2.1	2.1	7.6	11.1	9.7	9.7	5.6	9.7	5.6	8.3	6.3	12.5	4.2	5.6	0.0	0.0	13.5	6.1
	12	1.4	5.6	4.9	11.2	7.0	6.3	6.3	9.1	6.3	7.0	5.6	19.6	5.6	3.5	0.7	0.0	14.3	6.4
U	13	1.4	5.5	9.0	7.6	4.1	4.8	6.2	7.6	8.3	8.3	10.3	16.6	2.8	5.5	2.1	0.0	15.0	6.7
	14	0.0	6.2	8.3	9.7	4.1	4.8	3.4	9.0	6.9	9.7	9.7	15.9	6.2	3.4	2.1	0.7	15.3	6.8
R	15	0.0	6.9	6.9	4.1	7.6	4.8	2.8	13.1	11.0	8.3	7.6	15.9	5.5	2.1	3.4	0.0	15.2	6.8
	16	0.7	4.1	6.2	9.7	4.8	9.0	4.1	9.0	9.0	6.2	13.8	13.1	5.5	2.8	1.4	0.7	14.9	6.7
	17	0.0	2.8	9.0	8.3	9.7	6.9	6.9	9.7	9.7	6.9	11.7	11.7	2.1	4.8	0.0	0.0	13.8	6.2
	18	0.0	3.4	7.6	11.7	7.6	9.0	14.5	8.3	7.6	4.8	9.0	11.0	2.1	2.8	0.7	0.0	12.9	5.8
	19	0.0	3.4	5.5	12.4	11.0	13.8	11.7	8.3	5.5	5.5	6.2	13.1	0.0	2.1	1.4	0.0	12.4	5.5
	20	0.0	2.1	6.9	9.7	15.2	10.3	14.5	8.3	4.1	6.2	5.5	13.8	1.4	1.4	0.7	0.0	12.4	5.5
	21	0.0	2.8	10.3	10.3	13.1	11.0	6.9	12.4	6.9	6.9	2.1	11.7	4.1	0.7	0.7	0.0	12.2	5.4
	22	0.0	1.4	10.3	10.3	16.6	12.4	9.7	6.2	5.5	7.6	5.5	9.7	2.1	2.1	0.0	0.7	12.1	5.4
	23	0.0	2.8	4.9	14.1	17.6	10.6	9.9	8.5	7.0	2.8	4.9	10.6	3.5	1.4	0.0	1.4	12.3	5.5
	24	0.0	4.3	10.7	12.1	7.1	17.1	8.6	6.4	7.9	7.1	3.6	8.6	4.3	2.1	0.0	0.0	11.8	5.3
ALL HOURS		0.3	3.6	7.7	10.9	10.4	10.8	8.3	8.8	6.6	6.9	6.4	12.6	3.6	2.3	0.6	0.3	13.0	5.8

SOURCE: GEORESEARCH, INC.

Table IV - 9

Percentage Frequency Summary for Wind Speed

BLAINE COUNTY - HAYS

(SPRING)

01/01/84 - 07/15/85

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (METERS/SECOND)																	
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.1	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.5	2.7	8.7	20.1	18.5	9.8	8.2	4.9	5.4	5.4	5.4	7.1	1.6	0.5	1.1	0.0	10.5	4.7
	2	0.5	0.5	14.1	20.1	12.0	10.9	7.1	10.9	4.9	4.9	4.9	7.1	0.0	1.6	0.5	0.0	10.5	4.7
	3	0.5	1.6	11.4	14.1	17.4	13.0	9.8	9.8	4.3	2.2	6.0	6.5	2.2	0.0	1.1	0.0	10.6	4.7
	4	0.5	1.1	9.8	16.8	19.6	14.1	7.1	10.9	3.8	3.3	3.3	5.4	2.7	0.0	1.1	0.5	10.5	4.7
	5	0.5	1.1	8.2	18.5	18.5	15.8	8.2	6.5	5.4	6.0	2.2	5.4	1.6	0.5	0.5	1.1	10.5	4.7
	6	0.5	1.1	6.0	16.4	20.2	19.1	8.2	8.2	4.4	3.8	3.3	3.8	3.8	1.1	0.0	0.0	10.4	4.6
	7	0.5	1.6	9.9	14.8	21.4	13.7	7.1	9.3	6.0	3.8	4.4	4.9	1.1	1.1	0.0	0.0	10.2	4.5
	8	0.5	3.8	12.6	16.5	15.4	11.0	6.0	7.7	6.0	6.0	3.8	6.0	1.1	1.6	1.6	0.0	10.6	4.7
H	9	1.1	2.2	14.3	13.2	10.4	9.3	9.3	6.6	7.1	8.8	4.4	8.8	1.6	0.5	1.1	1.1	11.7	5.2
	10	0.5	2.2	9.3	13.7	9.3	10.4	11.5	8.2	2.7	6.0	4.9	13.2	3.3	2.7	0.5	1.1	12.7	5.7
O	11	1.1	1.6	8.2	9.9	11.0	11.5	7.7	8.2	4.9	5.5	8.8	12.6	3.8	3.3	1.6	0.0	13.6	6.1
	12	0.5	1.6	7.1	14.8	7.1	8.8	9.9	7.1	3.3	8.8	7.1	15.4	2.2	4.9	1.1	0.0	13.7	6.1
U	13	0.5	0.5	9.2	7.6	10.9	10.3	6.5	7.1	8.7	9.2	8.2	12.5	3.8	3.3	1.1	0.5	14.1	6.3
	14	0.5	1.1	4.3	8.2	10.3	9.8	8.7	9.2	7.6	11.4	9.2	10.3	4.9	2.7	1.6	0.0	14.5	6.5
R	15	0.5	0.5	5.4	8.2	10.3	6.5	10.9	10.3	10.3	9.2	8.2	10.3	5.4	3.8	0.0	0.0	14.4	6.4
	16	1.1	0.0	4.9	10.3	8.2	7.1	10.9	8.2	13.6	7.6	6.5	13.6	4.9	2.7	0.5	0.0	14.4	6.4
	17	0.0	0.5	4.9	7.6	8.7	10.9	8.7	11.4	9.2	8.7	8.2	12.0	5.4	3.3	0.5	0.0	14.6	6.5
	18	0.0	0.5	6.0	5.4	13.0	9.8	9.2	13.6	9.8	8.7	5.4	10.9	5.4	1.6	0.5	0.0	13.8	6.2
	19	0.0	0.0	6.5	9.8	12.5	11.4	12.5	10.9	6.5	5.4	7.1	10.9	4.9	1.1	0.5	0.0	13.1	5.9
	20	0.5	1.6	3.8	9.8	17.5	18.0	14.2	10.4	1.6	6.6	3.8	7.1	3.3	0.5	1.1	0.0	11.7	5.2
	21	1.1	2.2	7.1	10.9	18.0	20.8	12.0	9.3	3.8	2.2	3.3	6.0	2.2	1.1	0.0	0.0	10.6	4.7
	22	1.6	1.1	7.1	11.5	20.3	19.2	9.9	8.8	5.5	4.9	3.3	3.8	2.7	0.0	0.0	0.0	10.3	4.6
	23	1.1	1.1	3.9	17.7	15.5	19.3	11.6	7.7	4.4	6.1	3.9	6.6	1.1	0.0	0.0	0.0	10.4	4.7
	24	0.6	2.2	5.6	19.4	17.2	12.8	7.8	6.7	6.1	6.7	5.6	6.7	1.7	1.1	0.0	0.0	10.7	4.8
ALL HOURS		0.6	1.4	7.9	13.1	14.3	12.6	9.3	8.8	6.1	6.3	5.5	8.6	3.0	1.6	0.7	0.2	12.0	5.4

SOURCE: GEORESEARCH, INC.

Table IV - 10

Percentage Frequency Summary for Wind Speed

BLAINE COUNTY - HAYS

(SUMMER)

01/01/84 - 07/15/85

		WIND SPEED (MPH)																	
			0.1-	2.1-	4.1-	6.1-	8.1-	10.1-	12.1-	14.1-	16.1-	18.1-	20.1-	25.1-	30.1-	35.1-			
		CALM	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	35.0	40.0	>40.0		
		WIND SPEED (METERS/SECOND)																AV	AV
			0.1-	0.9-	1.8-	2.7-	3.6-	4.5-	5.4-	6.3-	7.2-	8.1-	9.0-	11.2-	13.5-	15.7-		SPEED	SPEED
		CALM	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.0	8.9	11.2	13.4	15.6	17.9	>17.9	(MPH)	(M/SEC)
	1	0.0	0.0	7.1	14.2	23.0	17.7	14.2	8.0	7.1	4.4	1.8	2.7	0.0	0.0	0.0	0.0	9.7	4.3
	2	0.9	0.9	11.5	15.0	15.9	20.4	13.3	11.5	1.8	1.8	2.7	2.7	0.9	0.9	0.0	0.0	9.3	4.1
	3	1.8	1.8	11.5	17.7	16.8	23.0	11.5	4.4	1.8	3.5	1.8	2.7	0.9	0.9	0.0	0.0	8.7	3.9
	4	1.8	0.9	11.5	26.5	18.6	15.9	8.8	5.3	2.7	2.7	0.9	3.5	0.0	0.0	0.9	0.0	8.4	3.8
	5	0.9	0.9	16.1	22.3	21.4	16.1	8.0	2.7	2.7	1.8	0.0	5.4	0.0	1.8	0.0	0.0	8.4	3.7
	6	0.9	0.9	13.4	20.5	17.9	22.3	9.8	4.5	2.7	0.0	2.7	2.7	0.0	0.9	0.9	0.0	8.6	3.8
	7	0.9	4.5	10.7	25.0	25.0	12.5	7.1	6.3	0.9	2.7	1.8	2.7	0.0	0.0	0.0	0.0	7.9	3.5
	8	0.9	3.6	14.3	21.4	17.0	9.8	8.9	6.3	6.3	2.7	6.3	2.7	0.0	0.0	0.0	0.0	8.8	3.9
H	9	0.0	2.7	12.6	18.9	13.5	11.7	9.0	5.4	4.5	8.1	4.5	6.3	2.7	0.0	0.0	0.0	10.4	4.6
	10	0.0	2.7	13.5	15.3	9.9	12.6	5.4	11.7	4.5	4.5	4.5	9.9	4.5	0.0	0.0	0.9	11.3	5.1
O	11	0.0	0.9	12.8	12.8	12.8	9.2	10.1	7.3	7.3	7.3	4.6	9.2	4.6	0.9	0.0	0.0	11.9	5.3
	12	0.9	0.0	11.1	20.4	9.3	6.5	9.3	6.5	7.4	7.4	7.4	8.3	4.6	0.9	0.0	0.0	11.8	5.3
U	13	0.9	0.0	6.3	18.8	9.8	11.6	5.4	13.4	5.4	6.3	7.1	13.4	0.0	1.8	0.0	0.0	12.1	5.4
	14	0.0	0.0	3.6	12.6	15.3	10.8	8.1	11.7	8.1	6.3	8.1	14.4	0.0	0.9	0.0	0.0	12.7	5.7
R	15	0.0	0.0	3.6	10.8	13.5	11.7	10.8	6.3	15.3	0.9	9.9	13.5	2.7	0.9	0.0	0.0	13.1	5.8
	16	0.0	0.0	2.7	12.6	18.0	4.5	9.9	9.9	8.1	9.9	5.4	14.4	4.5	0.0	0.0	0.0	13.3	5.9
	17	0.0	0.0	3.6	10.8	12.6	18.0	6.3	10.8	8.1	7.2	3.6	18.0	0.9	0.0	0.0	0.0	12.8	5.7
	18	0.9	1.8	2.7	9.0	12.6	9.9	10.8	12.6	9.0	9.0	6.3	14.4	0.9	0.0	0.0	0.0	12.8	5.7
	19	0.9	1.8	2.7	9.9	4.5	13.5	11.7	18.9	10.8	6.3	8.1	9.9	0.9	0.0	0.0	0.0	12.7	5.7
	20	0.0	0.9	1.8	5.5	14.5	10.0	18.2	10.9	11.8	10.9	4.5	9.1	0.0	1.8	0.0	0.0	13.0	5.8
	21	0.0	0.9	4.5	6.4	16.4	22.7	18.2	9.1	6.4	5.5	4.5	1.8	0.0	3.6	0.0	0.0	11.2	5.0
	22	0.9	0.0	2.8	13.8	20.2	27.5	13.8	8.3	2.8	3.7	1.8	3.7	0.9	0.0	0.0	0.0	9.9	4.4
	23	0.9	0.0	4.6	11.0	23.9	20.2	19.3	10.1	1.8	0.9	1.8	5.5	0.0	0.0	0.0	0.0	9.8	4.4
	24	0.9	0.0	8.3	11.9	20.2	21.1	16.5	8.3	4.6	3.7	1.8	2.8	0.0	0.0	0.0	0.0	9.4	4.2
ALL HOURS		0.6	1.1	8.1	15.2	16.0	15.0	11.0	8.7	5.9	4.9	4.2	7.5	1.2	0.6	0.1	0.0	10.7	4.8

SOURCE: GEORESEARCH, INC.

Table IV - 11

Percentage Frequency Summary for Wind Speed

BLAINE COUNTY - HAYS

(AUTUMN)

01/01/84 - 07/15/85

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	AV SPEED (MPH)	AV SPEED (M/SEC)
			WIND SPEED (METERS/SECOND)																
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	6.0	6.0	18.0	22.0	6.0	4.0	4.0	12.0	8.0	4.0	10.0	0.0	0.0	0.0	0.0	10.5	4.7
	2	0.0	6.0	10.0	16.0	16.0	12.0	6.0	4.0	6.0	4.0	6.0	8.0	6.0	0.0	0.0	0.0	10.8	4.8
	3	0.0	4.0	2.0	14.0	20.0	16.0	6.0	12.0	8.0	0.0	2.0	14.0	0.0	2.0	0.0	0.0	11.2	5.0
	4	2.0	0.0	4.0	24.0	14.0	14.0	12.0	8.0	4.0	2.0	6.0	8.0	0.0	2.0	0.0	0.0	10.5	4.7
	5	2.0	2.0	6.0	12.0	22.0	14.0	18.0	4.0	0.0	2.0	8.0	8.0	0.0	2.0	0.0	0.0	10.5	4.7
	6	2.0	2.0	6.0	14.0	26.0	6.0	10.0	10.0	0.0	6.0	10.0	6.0	2.0	0.0	0.0	0.0	10.7	4.8
	7	4.0	0.0	8.0	12.0	20.0	12.0	14.0	4.0	6.0	4.0	6.0	8.0	2.0	0.0	0.0	0.0	10.8	4.8
	8	2.0	0.0	8.0	18.0	14.0	10.0	10.0	12.0	4.0	0.0	6.0	14.0	2.0	0.0	0.0	0.0	11.2	5.0
H	9	2.0	2.0	12.0	18.0	6.0	14.0	4.0	16.0	8.0	0.0	4.0	12.0	2.0	0.0	0.0	0.0	10.8	4.8
	10	2.0	12.0	2.0	10.0	10.0	16.0	6.0	10.0	4.0	6.0	4.0	16.0	2.0	0.0	0.0	0.0	11.4	5.1
O	11	0.0	4.0	10.0	10.0	8.0	8.0	12.0	12.0	0.0	6.0	6.0	20.0	4.0	0.0	0.0	0.0	13.0	5.8
	12	0.0	2.0	8.0	8.0	6.0	14.0	8.0	6.0	10.0	2.0	6.0	22.0	6.0	0.0	2.0	0.0	14.4	6.4
U	13	0.0	0.0	7.7	13.5	11.5	5.8	11.5	7.7	5.8	3.8	7.7	21.2	3.8	0.0	0.0	0.0	13.5	6.0
	14	1.9	0.0	7.7	7.7	7.7	7.7	19.2	5.8	7.7	9.6	7.7	11.5	1.9	3.8	0.0	0.0	13.4	6.0
R	15	1.9	0.0	7.7	11.5	5.8	7.7	15.4	9.6	13.5	5.8	3.8	9.6	3.8	1.9	1.9	0.0	13.3	5.9
	16	1.9	1.9	5.8	15.4	11.5	5.8	13.5	15.4	3.8	7.7	0.0	11.5	3.8	1.9	0.0	0.0	12.2	5.4
	17	1.9	3.8	7.7	13.5	3.8	21.2	9.6	5.8	9.6	0.0	5.8	13.5	0.0	3.8	0.0	0.0	12.0	5.4
	18	2.0	0.0	9.8	5.9	19.6	15.7	11.8	9.8	3.9	3.9	9.8	3.9	2.0	0.0	2.0	0.0	11.3	5.0
	19	0.0	3.9	15.7	9.8	17.6	11.8	13.7	5.9	2.0	7.8	5.9	2.0	2.0	2.0	0.0	0.0	10.2	4.5
	20	0.0	3.9	11.8	19.6	13.7	11.8	11.8	5.9	2.0	7.8	3.9	7.8	0.0	0.0	0.0	0.0	9.7	4.3
	21	0.0	3.9	11.8	19.6	7.8	15.7	13.7	7.8	5.9	2.0	5.9	5.9	0.0	0.0	0.0	0.0	9.7	4.3
	22	0.0	2.0	8.2	18.4	10.2	12.2	14.3	10.2	2.0	8.2	4.1	10.2	0.0	0.0	0.0	0.0	10.8	4.8
	23	0.0	10.2	8.2	16.3	12.2	12.2	6.1	6.1	4.1	8.2	6.1	10.2	0.0	0.0	0.0	0.0	10.4	4.6
	24	0.0	4.1	4.1	24.5	18.4	8.2	10.2	4.1	4.1	6.1	6.1	10.2	0.0	0.0	0.0	0.0	10.3	4.6
ALL HOURS		1.1	3.1	7.8	14.5	13.5	11.6	10.9	8.2	5.3	4.6	5.6	11.0	1.8	0.8	0.2	0.0	11.4	5.1

SOURCE: GEORESEARCH, INC.

Table IV - 12

Annual Wind Rose Distribution

BLAINE COUNTY - HAYS

01/01/84 - 07/15/85

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.7	0.1- 0.4
1.1- 2.0	0.1	0.2	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	1.6	0.5- 0.9
2.1- 3.0	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	2.5	1.0- 1.3 S
3.1- 4.0	0.1	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.4	0.4	0.8	0.4	0.4	0.1	0.2	0.2	5.1	1.4- 1.8 P
S 4.1- 5.0	0.2	0.2	0.5	0.4	0.3	0.2	0.2	0.3	0.4	0.6	0.8	0.5	0.3	0.2	0.2	0.2	5.5	1.9- 2.2 E
P 5.1- 6.0	0.5	0.4	0.4	0.5	0.4	0.3	0.2	0.3	0.3	1.0	1.5	0.8	0.3	0.1	0.2	0.3	7.4	2.3- 2.7 E
E 6.1- 7.0	0.2	0.3	0.5	0.3	0.3	0.2	0.1	0.2	0.5	0.9	0.9	0.8	0.3	0.1	0.3	0.3	6.2	2.8- 3.1 D
E 7.1- 8.0	0.3	0.4	0.4	0.5	0.3	0.2	0.2	0.2	0.6	0.9	1.0	0.8	0.4	0.3	0.2	0.3	7.1	3.2- 3.6
D 8.1- 9.0	0.3	0.3	0.4	0.3	0.2	0.2	0.1	0.2	0.7	0.6	0.8	0.7	0.3	0.1	0.1	0.4	5.6	3.7- 4.0 M
9.1-10.0	0.3	0.3	0.3	0.2	0.3	0.2	0.1	0.1	0.7	0.7	0.9	0.8	0.3	0.3	0.3	0.3	6.2	4.1- 4.5 E
M 10.1-11.0	0.2	0.1	0.3	0.2	0.2	0.1	0.1	0.0	0.3	0.3	0.8	0.5	0.2	0.3	0.3	0.4	4.2	4.6- 4.9 T
I 11.1-12.0	0.1	0.3	0.3	0.2	0.2	0.0	0.1	0.0	0.3	0.5	0.8	0.5	0.3	0.2	0.4	0.3	4.7	5.0- 5.4 E
L 12.1-13.0	0.1	0.1	0.2	0.1	0.2	0.0	0.1	0.0	0.1	0.4	0.8	0.4	0.2	0.2	0.4	0.3	3.8	5.5- 5.8 R
E 13.1-14.0	0.1	0.1	0.3	0.1	0.2	0.1	0.1	0.1	0.2	0.5	0.9	0.5	0.2	0.3	0.5	0.3	4.5	5.9- 6.3 S
S 14.1-15.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.3	0.5	0.3	0.2	0.2	0.4	0.3	3.0	6.4- 6.7 /
/ 15.1-16.0	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.2	0.3	0.6	0.3	0.2	0.1	0.5	0.3	3.0	6.8- 7.2 S
H 16.1-17.0	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.3	0.6	0.5	0.2	0.2	0.4	0.4	3.1	7.3- 7.6 E
O 17.1-18.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.3	0.7	0.3	0.1	0.3	0.5	0.3	2.8	7.7- 8.0 C
U 18.1-19.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.4	0.8	0.4	0.2	0.3	0.5	0.3	3.4	8.1- 8.5 O
R 19.1-20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.4	0.4	0.2	0.2	0.5	0.3	2.5	8.6- 8.9 N
20.1-25.0	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.4	0.8	2.4	1.3	0.7	0.7	1.8	1.0	9.8	9.0-11.2 D
25.1-30.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.8	1.0	0.4	0.3	0.5	0.2	3.6	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.3	0.1	0.2	0.1	1.6	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.0	0.0	0.8	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	>17.9
CALM																	0.8	CALM
TOTAL	3.5	4.0	4.7	3.7	3.5	2.5	2.1	2.2	6.1	10.2	17.9	12.6	6.1	4.9	8.6	6.5	100.0	TOTAL
AV SPEED (MPH)	9.6	9.1	8.8	8.1	9.6	8.3	7.7	6.7	9.8	11.3	13.5	14.4	14.4	15.3	16.3	13.6	12.2	AV SPEED (MPH)
AV SPEED (M/SEC)	4.3	4.1	3.9	3.6	4.3	3.7	3.5	3.0	4.4	5.1	6.0	6.4	6.5	6.8	7.3	6.1	5.4	AV SPEED (M/SEC)

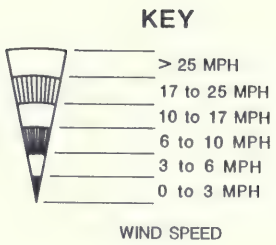
SOURCE: GEORESEARCH, INC.

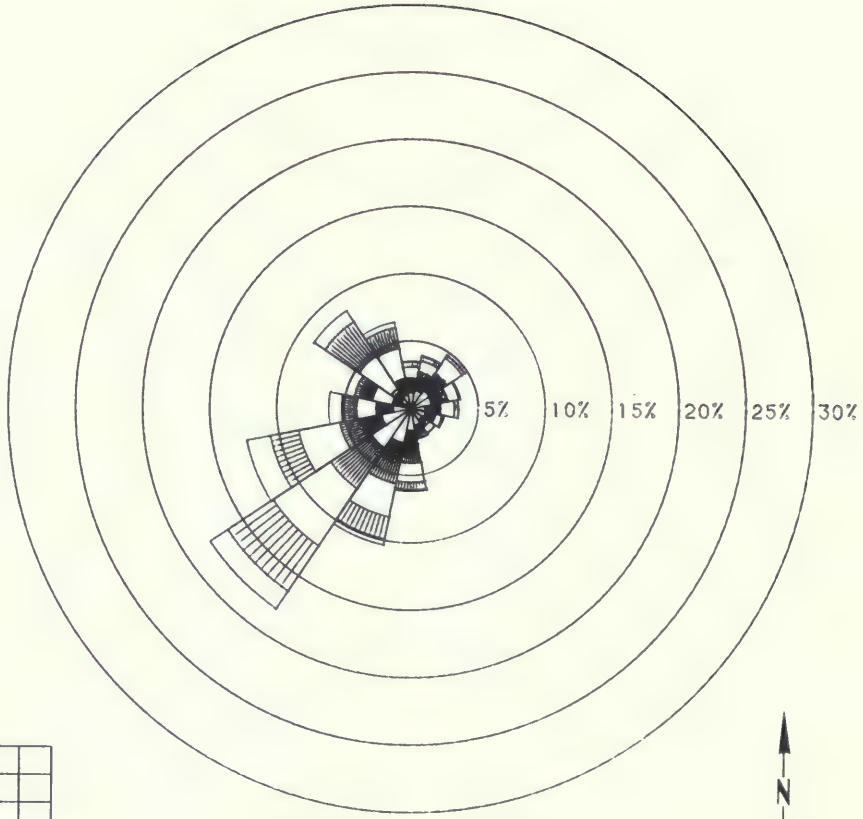
Figure IV - 1

Annual Wind Rose

BLAINE COUNTY - HAYS

(1984 - 1985)





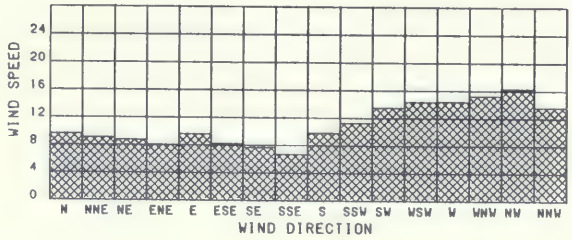


Table IV - 13

Coefficients of Weibull Distribution

BLAINE COUNTY - HAYS

01/01/84 - 07/15/85

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	6.7675	1.5802
FEBRUARY	6.1154	1.7294
MARCH	5.0212	1.7592
APRIL	6.3888	1.7118
MAY	5.5188	1.8030
JUNE	5.7674	1.8076
JULY	4.6313	2.0507
AUGUST	4.1845	2.0401
SEPTEMBER	3.8593	2.0669
OCTOBER	5.5662	1.7356
NOVEMBER	6.9981	1.5790
DECEMBER	7.0125	1.4357
YEAR	5.6748	1.7143

SOURCE: GEORESEARCH, INC.

THREE FORKS
BROADWATER COUNTY

The Three Forks site was located approximately 6 miles north-northwest of the town of Three Forks at 45 59 20 N and 111 35 32 W (Site No. 10 on Map II-1). The site was located on a hill in gently rolling terrain at an elevation of 4,580 feet. The site was established by the U.S. Bureau of Reclamation as part of its Northern Great Plains Wind Energy Study.

Wind data were gathered at this site from June 27, 1981, to September 15, 1982. Data from the wind sensors were continuously recorded on cassette tape at the site. These tapes were further processed by computer to yield hourly averages of wind speed, wind direction, the average cube of the hourly speed, and standard deviation of hourly wind speed. In addition, maximum and minimum instantaneous values of wind speed during each hour were recorded. Anemometer height was 10 meters. Prevailing winds from the southwest were accurately measured, but east winds were somewhat screened by a hill.

Data recovery was fair to excellent, ranging from 56.5 percent in July and 97.1 percent in June to 100.0 percent during all other months. Overall data recovery was 93.7 percent.

The average annual wind speed at this site was 8.6 miles per hour. Average monthly wind speeds varied from 6.4 miles per hour in June to 10.6 miles per hour in January. The windiest months were January through April.

Average monthly wind power ranged from 27.2 watts/m^2 in June to 139.0 watts/m^2 in January. Average annual wind power was 72.5 watts/m^2.

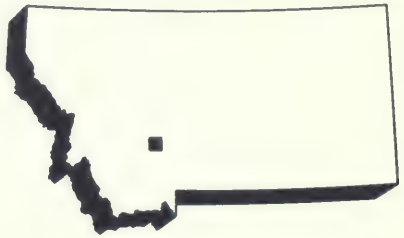


Table IV - 14

Monthly Wind Speed Distribution

BROADWATER COUNTY - THREE FORKS

06/27/81 - 09/15/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.0	0.3	1.3	0.3	0.0	0.5	0.1	0.5	1.0	0.4	0.1	0.3	0.4	0.1- 0.4
1.1-2.0	1.3	1.2	2.2	1.7	2.3	3.7	1.4	2.6	2.4	1.7	1.1	2.4	2.1	0.5- 0.9
2.1-3.0	5.1	3.9	4.6	3.9	7.0	10.9	3.6	6.9	6.7	5.8	5.7	6.7	6.0	1.0- 1.3
3.1-4.0	5.4	4.6	4.7	4.7	7.9	11.4	5.7	10.1	9.6	7.0	7.2	7.1	7.5	1.4- 1.8
4.1-5.0	6.0	6.5	6.0	7.4	12.1	15.5	10.2	16.0	12.7	10.3	8.6	10.2	10.7	1.9- 2.2
5.1-6.0	4.7	7.3	6.5	6.4	10.2	10.5	11.0	10.8	11.4	9.8	9.0	9.9	9.2	2.3- 2.7
6.1-7.0	7.5	12.2	9.3	10.3	10.2	14.8	11.5	10.9	11.9	13.3	11.7	11.0	11.2	2.8- 3.1
7.1-8.0	8.3	9.1	5.9	9.0	5.8	8.1	8.7	7.5	9.0	7.5	10.3	7.9	8.1	3.2- 3.6
8.1-9.0	9.9	13.2	9.3	10.0	6.5	7.3	10.0	7.5	7.5	7.5	14.9	9.3	9.2	3.7- 4.0
9.1-10.0	6.3	6.5	7.3	5.1	4.0	3.3	7.4	5.2	4.2	6.5	7.4	5.1	5.6	4.1- 4.5
10.1-11.0	7.9	7.9	5.5	7.1	4.3	3.7	6.1	5.5	6.4	3.6	8.9	6.3	6.0	4.6- 4.9
11.1-12.0	5.1	5.2	3.4	4.0	3.6	2.0	3.6	3.4	3.0	4.0	4.2	3.2	3.7	5.0- 5.4
12.1-13.0	3.9	4.8	4.8	4.9	4.0	1.9	5.1	2.5	1.9	4.3	2.8	3.2	3.5	5.5- 5.8
13.1-14.0	3.8	2.5	3.1	3.5	2.7	2.1	2.7	1.9	1.7	3.2	1.5	3.2	2.6	5.9- 6.3
14.1-15.0	3.9	3.1	3.8	3.3	3.4	1.4	1.8	1.9	2.7	1.7	1.8	3.6	2.6	6.4- 6.7
15.1-16.0	2.0	1.9	3.0	2.1	3.1	0.6	2.4	1.5	1.1	1.5	0.6	1.5	1.7	6.8- 7.2
16.1-17.0	2.4	1.2	2.7	2.1	2.6	0.6	1.4	1.5	0.6	1.1	0.8	2.3	1.6	7.3- 7.6
17.1-18.0	3.9	1.3	2.6	2.1	2.4	0.5	1.9	1.5	0.7	1.3	0.8	1.5	1.7	7.7- 8.0
18.1-19.0	2.4	1.6	1.7	1.4	1.6	0.3	1.1	0.5	0.6	2.2	0.3	0.7	1.1	8.1- 8.5
19.1-20.0	2.0	0.9	3.0	2.5	1.1	0.5	0.6	0.7	1.3	1.9	0.4	0.9	1.3	8.6- 8.9
20.1-25.0	5.0	3.3	6.7	7.1	3.9	0.4	2.9	1.1	3.3	3.9	1.1	2.2	3.2	9,0-11.2
25.1-30.0	1.9	0.7	1.9	0.8	0.8	0.1	0.8	0.0	0.4	1.3	0.7	1.2	0.8	11.3-13.4
30.1-35.0	0.7	0.6	0.5	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	13.5-15.6
35.1-40.0	0.1	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	10.6	9.3	10.4	10.1	8.9	6.4	8.8	7.3	7.6	8.8	8.0	8.5	8.6	
AVERAGE SPEED (M/SEC)	4.8	4.2	4.6	4.5	4.0	2.9	3.9	3.3	3.4	3.9	3.6	3.8	3.8	
AVERAGE WIND POWER (WATTS/M**2)	139.0	86.3	122.2	110.9	88.0	27.2	63.9	39.3	51.5	78.4	50.0	72.1	72.5	
PERCENT DATA RECOVERY	100.0	100.0	100.0	100.0	100.0	97.1	56.5	100.0	100.0	100.0	100.0	100.0	93.7	

SPEED / MEED / SPEED / MEED / SPEED / MEED /

GREAT FALLS MALMSTROM AFB

CASCADE COUNTY

Malmstrom Air Force Base is located on the eastern side of Great Falls at 47 31 12 N and 111 10 12 W (Site No. 14 on Map II-1). Elevation at the base is 3,465 feet. Meteorological data have been collected at this site for many years by the United States Air Force.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in anemometer height, the data set was broken into three parts for analysis: January 1, 1949, through May 31, 1953; March 1, 1954, through February 28, 1958; and April 1, 1958, through November 30, 1968. Only data from the most recent of these periods were selected for inclusion in the *Montana Wind Energy Atlas.*

The data set for Malmstrom Air Force Base consists of data summaries of observations made every third hour from April 1, 1958, through November 30, 1968. The anemometer was mounted on a ground mast at a height of 4.6 meters. The site is representative of lower lying areas in the vicinity of Great Falls.

Average annual wind speed was 8.7 miles per hour. Monthly average wind speeds ranged from 5.6 miles per hour in July to 10.7 miles per hour in January.

Average annual wind power was 106.0 watts/m^2. Average monthly wind power varied from 33.0 watts/m^2 in July to 175.0 watts/m^2 in January.

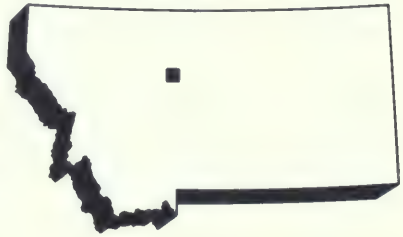


Table IV - 15

Monthly Wind Speed Distribution

CASCADE COUNTY - GREAT FALLS MALMSTROM AIR FORCE BASE

04/01/58 - 11/30/68

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	SPEED (KNOTS)
CALM (<1.1)	12.4	10.8	12.0	9.9	12.8	16.1	19.7	15.8	15.6	12.1	13.3	12.4	13.7	CALM (<0.5)
1.1- 3.1	5.7	5.2	5.9	5.9	6.9	8.0	10.4	8.3	7.6	5.1	5.4	6.2	6.8	0.5- 1.4
3.4- 5.4	10.4	10.9	13.2	12.9	16.3	20.2	22.8	20.5	16.7	11.6	10.4	11.6	14.9	1.5- 2.4
5.6- 7.6	11.2	13.8	14.4	14.8	16.4	17.1	18.4	18.1	17.2	13.1	12.8	13.2	15.1	2.5- 3.4
7.8- 9.8	10.6	11.9	12.3	13.9	13.2	12.9	11.9	13.1	13.3	13.3	10.7	11.5	12.4	3.5- 4.4
10.1-12.1	9.9	11.7	10.9	11.7	10.0	9.5	8.2	9.8	9.7	11.9	10.6	10.2	10.3	4.5- 5.4
12.3-14.3	9.6	9.1	9.3	8.9	7.8	6.6	3.7	6.0	6.2	9.2	9.8	8.5	7.8	5.5- 6.4
14.5-16.6	7.4	7.2	7.1	7.2	5.8	3.8	2.2	3.5	4.7	7.6	8.2	7.2	5.9	6.5- 7.4
16.8-18.8	7.1	6.4	5.4	5.2	4.4	2.3	1.4	2.4	3.5	6.2	6.7	6.4	4.7	7.5- 8.4
19.0-21.0	5.3	4.8	4.1	3.5	2.2	1.6	0.8	1.0	2.1	3.8	4.2	4.3	3.1	8.5- 9.4
21.3-23.3	4.3	3.4	2.9	3.0	2.1	1.1	0.3	0.8	1.7	2.8	3.3	3.4	2.4	9.5-10.4
23.5-25.5	2.3	1.8	1.2	1.2	0.9	0.4	0.1	0.4	0.7	1.2	1.7	2.0	1.1	10.5-11.4
25.7-27.7	1.7	1.2	0.6	0.9	0.5	0.3	0.1	0.2	0.4	0.9	1.2	1.3	0.8	11.5-12.4
28.0-30.0	1.2	0.9	0.5	0.7	0.4	0.1	0.0	0.2	0.2	0.7	0.8	1.0	0.6	12.5-13.4
30.2-32.2	0.6	0.3	0.1	0.2	0.1	0.0	0.0	0.0	0.1	0.3	0.4	0.3	0.2	13.5-14.4
32.4-34.4	0.3	0.3	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.3	0.1	14.5-15.4
34.7-36.7	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	15.5-16.4
36.9-38.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	10.7	10.3	9.4	9.6	8.3	6.9	5.6	6.7	7.6	9.8	10.3	10.1	8.7	
AVERAGE SPEED (M/SEC)	4.8	4.6	4.2	4.3	3.7	3.1	2.5	3.0	3.4	4.4	4.6	4.5	3.9	
AVERAGE WIND POWER (WATTS/M**2)	175.0	150.0	114.0	120.0	87.0	55.0	33.0	51.0	76.0	126.0	150.0	148.0	106.0	

SPEED (MPH / KNOTS): S P E E D M I L E S / H O U R

SPEED (KNOTS): S P E E D K N O T S

ANEMOMETER HEIGHT = 15.0 FEET = 4.6 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

GREAT FALLS NWS AIRPORT

CASCADE COUNTY

Great Falls International Airport is located about 4 miles southwest of Great Falls at 47 28 48 N and 111 22 12 W (Site No. 15 on Map II-1). Elevation at the airport is 3,688 feet. Meteorological data have been collected at this site for many years by the National Weather Service.

The site is located on a high, exposed bench between the Sun River valley to the north and the Missouri River valley to the south and east. The bench is occupied by the airport, by housing developments, and by farmland. Interstate Highway 15 runs past the site. Great Falls is an important communications and electric power generation center. It also is a major center of aviation, both commercial and military (at Malmstrom Air Force Base).

The data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in anemometer height and reporting intervals, the data set was split into three parts for analysis: January 1, 1948, through February 2, 1959; February 3, 1959, through December 31, 1964; and January 1, 1965, through December 31, 1978. Only data from the most recent of these periods were selected for inclusion in the *Montana Wind Energy Atlas.*

The data set for the Great Falls airport consists of data summaries of observations made every third hour from January 1, 1965, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 6.7 meters. The site is representative of the higher, more exposed areas around Great Falls.

Average annual wind speed was 11.9 miles per hour. Average monthly wind speeds varied from 9.4 miles per hour in July to 14.8 miles per hour in December.

Average annual wind power was 183.0 watts/m². Monthly average wind power ranged from 77 watts/m² in July to 324 watts/m² in December.

Average seasonal wind speeds were 9.8 miles per hour in summer, 11.9 miles per hour in spring, 12.2 miles per hour in autumn, and 13.9 miles per hour in winter. During the summer, the highest average wind speeds occurred during the late afternoon. During all other seasons, the highest average wind speeds occurred in early to mid-afternoon. The lowest average wind speeds occurred about 0600 MST during spring and summer, around 0300 MST in autumn, and from 2100 to 2400 MST in winter. Diurnal range of average wind speed was nearly equal for all seasons, except for the winter.

Winds were most common from the south-southwest through west-southwest; they blew from this sector nearly half the time. Winds from the southeast through south-southeast were least common. By direction, the average wind speeds ranged from 6.5 miles per hour for winds from the southeast to 15.7 miles per hour for southwesterly winds. The strongest winds blew from the prevailing wind directions.

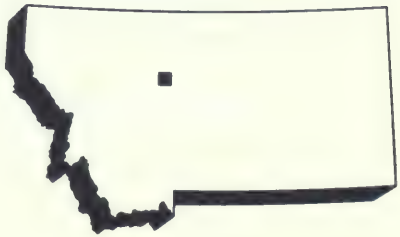


Table IV - 16

Monthly Wind Speed Distribution

CASCADE COUNTY - GREAT FALLS NWS AIRPORT

01/01/65 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	2.2	2.3	2.3	1.7	1.9	1.8	1.8	1.7	1.5	1.2	2.4	1.8	1.9	CALM (<0.5)
1.1- 3.1	2.0	1.2	2.0	1.9	1.6	2.0	1.2	1.4	1.1	0.8	2.1	1.4	1.6	0.5- 1.4
3.4- 5.4	11.3	8.6	9.0	9.3	10.3	11.4	12.5	11.0	10.2	6.9	7.9	7.9	9.7	1.5- 2.4 S
S 5.6- 7.6	13.7	13.8	13.6	13.9	17.7	18.1	24.3	23.5	19.3	14.2	12.8	11.1	16.4	2.5- 3.4 P
P 7.8- 9.8	11.1	12.3	13.8	16.8	17.8	20.2	24.4	23.3	21.0	15.7	13.1	11.1	16.7	3.5- 4.4 E
E 10.1-12.1	10.4	11.8	13.4	15.3	16.4	16.0	14.5	16.0	15.9	14.8	13.4	11.0	14.1	4.5- 5.4 E
E 12.3-14.3	8.6	10.5	10.2	10.9	9.3	9.5	7.9	8.4	10.4	11.0	10.0	9.2	9.6	5.5- 6.4 D
D 14.5-16.6	7.7	9.6	9.4	8.9	8.4	6.8	5.1	5.7	6.8	11.3	8.4	8.3	8.0	6.5- 7.4
16.8-18.8	8.2	8.0	7.9	8.1	6.1	5.4	3.8	3.8	5.8	8.5	8.5	9.8	7.0	7.5- 8.4 M
M 19.0-21.0	6.3	6.9	5.8	4.8	4.4	3.4	1.8	2.1	3.5	4.8	6.3	7.6	4.8	8.5- 9.4 E
I 21.3-23.3	5.9	5.3	4.6	3.7	2.7	2.6	1.2	1.3	2.0	3.8	5.7	6.2	3.7	9.5-10.4 T
L 23.5-25.5	3.1	2.9	2.6	1.6	1.1	1.1	0.4	0.7	1.1	2.8	2.6	4.1	2.0	10.5-11.4 E
E 25.7-27.7	2.8	2.7	1.9	1.4	1.0	0.7	0.5	0.6	0.9	1.4	2.3	3.4	1.6	11.5-12.4 R
S 28.0-30.0	2.5	1.9	1.8	0.9	1.0	0.6	0.2	0.5	0.4	1.6	2.3	3.0	1.4	12.5-13.4 S
/ 30.2-32.2	1.7	1.0	0.5	0.2	0.3	0.2	0.1	0.1	0.1	0.6	1.1	1.7	0.7	13.5-14.4 /
H 32.4-34.4	1.0	0.6	0.6	0.4	0.1	0.1	0.1	0.1	0.0	0.3	0.4	1.3	0.4	14.5-15.4 S
O 34.7-36.7	0.5	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.4	0.2	15.5-16.4 E
U 36.9-38.9	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.1	16.5-17.4 C
R 39.1-41.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	17.5-18.4 O
41.4-43.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	19.5-20.4 D
45.9-56.8	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	13.6	13.2	12.8	11.9	11.0	10.5	9.4	9.6	10.5	12.8	13.2	14.8	11.9	
AVERAGE SPEED (M/SEC)	6.1	5.9	5.7	5.3	4.9	4.7	4.2	4.3	4.7	5.7	5.9	6.6	5.3	
AVERAGE WIND POWER (WATTS/M**2)	298.0	247.0	217.0	163.0	133.0	113.0	77.0	84.0	111.0	192.0	241.0	324.0	183.0	

ANEMOMETER HEIGHT = 22.0 FEET = 6.7 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 17

Percentage Frequency Summary For Wind Speed

CASCADE COUNTY - GREAT FALLS NWS AIRPORT (WINTER)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	3.0	1.6	10.5	12.2	12.2	11.3	10.1	7.7	9.3	6.7	5.9	2.9	2.4	2.1	0.9	1.3	13.1	5.9
	6	2.4	1.4	9.8	13.0	11.3	11.9	9.4	8.9	9.6	6.6	4.7	3.2	2.7	2.0	1.1	2.0	13.4	6.0
O	9	2.2	2.2	9.3	13.1	11.2	10.7	10.5	9.9	7.5	6.5	5.8	3.4	2.4	2.2	1.0	1.9	13.6	6.1
	12	1.9	1.2	9.1	10.6	10.0	8.5	8.4	8.5	9.3	8.2	7.3	4.4	3.9	3.5	2.6	2.6	15.2	6.8
U	15	1.5	1.4	7.8	10.8	11.2	9.1	7.5	6.9	8.2	7.9	7.8	4.5	5.4	3.7	2.7	3.7	15.9	7.1
	18	1.8	1.4	9.1	13.1	13.0	11.4	9.3	8.9	7.9	6.4	5.9	3.2	2.9	2.2	1.6	1.7	13.7	6.1
R	21	1.9	1.6	8.8	15.3	12.5	12.4	10.1	8.8	8.3	7.2	4.3	2.5	1.9	1.7	1.1	1.7	13.0	5.8
	24	2.1	1.6	10.1	14.5	10.6	13.0	9.6	8.4	9.4	5.7	4.9	3.4	2.1	2.1	0.8	1.5	13.0	5.8
ALL HOURS		2.1	1.5	9.3	12.8	11.5	11.0	9.4	8.5	8.7	6.9	5.8	3.4	3.0	2.5	1.5	2.0	13.9	6.2

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 18

Percentage Frequency Summary For Wind Speed

CASCADE COUNTY - GREAT FALLS NWS AIRPORT (SPRING)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV	AV
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	SPEED (MPH)	SPEED (M/SEC)
H	3	3.2	2.3	9.9	17.3	20.8	17.5	9.6	7.6	5.7	3.1	1.4	0.6	0.5	0.3	0.0	0.3	10.2	4.6
	6	3.4	2.5	12.0	18.5	17.5	14.3	11.3	8.5	5.3	2.7	2.3	1.0	0.4	0.3	0.2	0.0	10.1	4.5
O	9	2.5	2.0	10.7	13.7	13.1	12.4	12.0	9.4	8.8	6.0	4.8	1.8	1.4	1.0	0.1	0.3	12.0	5.4
	12	1.3	1.4	10.0	12.8	11.9	12.2	8.6	9.3	9.2	6.6	6.2	2.9	3.0	2.6	0.7	1.5	13.6	6.1
U	15	0.8	1.4	7.0	12.0	12.8	14.2	7.5	9.9	9.4	7.7	5.6	3.4	3.0	2.7	0.8	1.8	14.2	6.4
	18	1.2	1.3	6.2	10.0	14.3	13.3	10.9	11.5	8.0	7.7	5.8	3.3	2.4	2.1	0.9	1.0	13.9	6.2
R	21	1.2	1.2	10.7	17.2	19.4	16.9	11.6	8.0	6.7	3.0	2.3	0.7	0.4	0.4	0.0	0.3	10.7	4.8
	24	1.9	2.5	9.9	19.0	19.2	19.4	9.5	7.1	5.7	3.2	1.3	0.5	0.4	0.3	0.0	0.2	10.2	4.6
ALL HOURS		2.0	1.8	9.5	15.1	16.1	15.0	10.1	8.9	7.4	5.0	3.7	1.8	1.4	1.2	0.3	0.7	11.9	5.3

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 19

Percentage Frequency Summary For Wind Speed

CASCADE COUNTY - GREAT FALLS NWS AIRPORT (SUMMER)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	3.1	1.6	14.2	27.9	25.3	13.7	6.9	4.1	2.1	0.7	0.5	0.0	0.0	0.0	0.0	0.0	8.2	3.7
	6	3.7	2.1	15.8	26.3	25.9	14.0	5.2	3.5	1.7	1.0	0.5	0.2	0.0	0.1	0.0	0.0	8.0	3.6
O	9	1.8	2.1	13.8	20.2	19.7	14.3	10.3	5.4	5.7	3.2	1.9	0.7	0.3	0.6	0.0	0.0	10.0	4.5
	12	1.3	1.2	11.1	20.3	20.4	14.1	9.5	7.2	5.4	3.6	2.4	0.6	1.7	0.9	0.1	0.1	10.6	4.7
U	15	0.6	1.0	9.4	16.0	20.7	15.8	9.6	7.8	7.3	3.6	3.4	1.7	1.3	0.8	0.6	0.3	11.5	5.2
	18	1.1	1.0	8.1	14.4	17.9	16.7	11.1	9.7	7.1	4.3	3.6	2.2	1.4	0.8	0.6	0.3	12.1	5.4
R	21	1.4	1.5	9.3	22.9	24.2	18.1	10.1	4.8	3.9	2.1	1.2	0.2	0.2	0.1	0.0	0.1	9.6	4.3
	24	1.2	1.6	11.3	28.3	27.3	17.3	6.1	4.3	1.4	0.7	0.2	0.2	0.1	0.2	0.0	0.0	8.6	3.8
ALL HOURS		1.8	1.5	11.6	22.0	22.7	15.5	8.6	5.9	4.3	2.4	1.7	0.7	0.6	0.4	0.1	0.1	9.8	4.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 20

Percentage Frequency Summary for Wind Speed

CASCADE COUNTY - GREAT FALLS NWS AIRPORT (AUTUMN)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	2.7	2.0	9.6	17.0	19.9	14.4	12.1	7.5	5.9	2.8	2.7	0.9	0.9	0.9	0.4	0.4	10.8	4.8
	6	2.1	1.5	10.2	17.8	16.6	16.1	10.9	9.2	6.4	3.4	2.8	1.2	0.6	0.6	0.2	0.3	11.0	4.9
O	9	2.7	1.4	9.0	16.9	13.7	15.0	9.8	9.5	8.2	5.5	2.6	2.4	1.2	1.2	0.5	0.4	11.8	5.3
	12	1.7	1.5	8.0	11.2	11.1	11.0	9.4	9.2	10.8	6.7	6.1	4.2	3.3	3.5	1.3	1.0	14.4	6.4
U	15	0.8	0.8	7.2	11.3	12.2	11.2	9.9	9.0	10.0	7.0	7.8	4.0	3.3	2.8	1.2	1.5	14.7	6.6
	18	0.7	0.9	6.4	14.8	17.0	14.4	11.4	9.5	8.5	5.6	3.5	2.8	1.7	1.5	0.7	0.4	12.7	5.7
R	21	1.0	1.4	7.2	16.3	21.9	17.7	10.2	8.9	6.2	4.2	2.3	0.9	0.6	0.6	0.3	0.2	11.2	5.0
	24	1.7	1.2	8.8	18.0	20.1	17.7	10.0	8.2	4.9	3.4	2.9	1.2	0.7	0.7	0.3	0.3	11.0	4.9
ALL HOURS		1.7	1.3	8.3	15.4	16.6	14.7	10.5	8.9	7.6	4.9	3.8	2.2	1.5	1.4	0.6	0.6	12.2	5.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 21

Annual Wind Rose Distribution

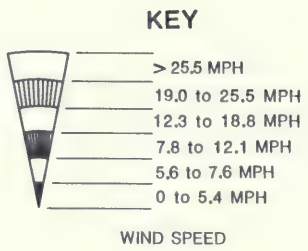
CASCADE COUNTY - GREAT FALLS NWS AIRPORT

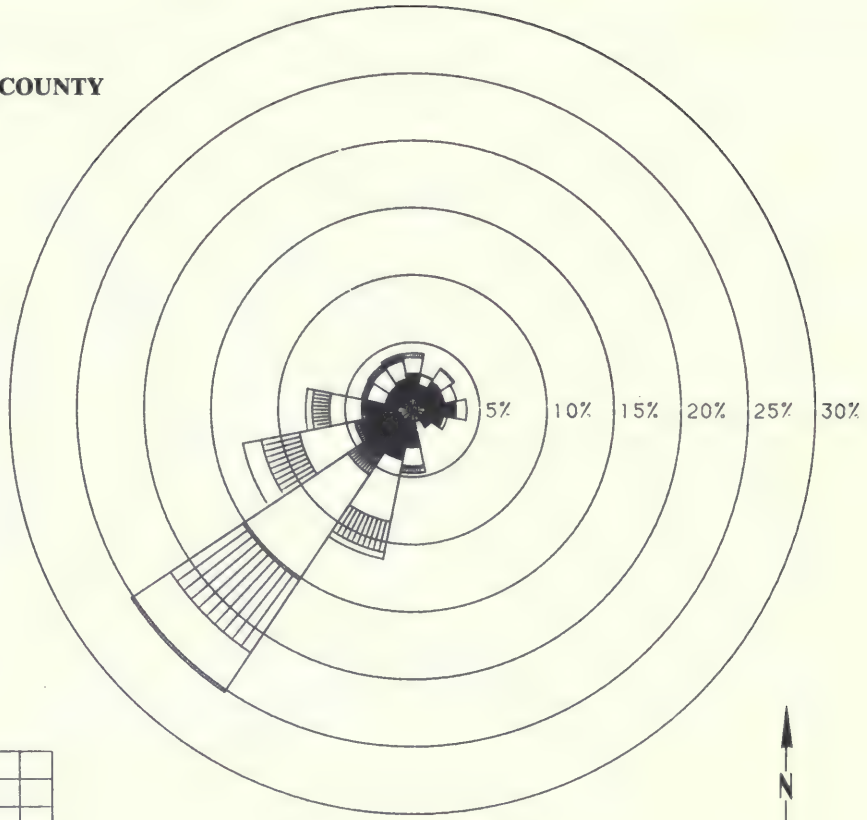
01/01/65 - 12/31/78

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4
3.4- 5.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	1.6	1.5- 2.4
S 5.6- 7.6	0.7	0.5	0.5	0.5	0.8	0.7	0.5	0.3	0.7	0.6	0.8	0.8	0.9	0.5	0.4	0.5	9.7	2.5- 3.4
P 7.8- 9.8	1.0	0.7	1.0	0.9	1.3	0.9	0.6	0.3	1.0	1.2	2.0	1.7	1.4	0.7	0.8	0.9	16.4	3.5- 4.4
E 10.1-12.1	0.9	0.6	0.9	0.9	1.0	0.6	0.3	0.2	1.0	1.9	2.9	1.8	1.3	0.8	0.8	0.8	16.7	4.5- 5.4
E 12.3-14.3	0.6	0.4	0.6	0.6	0.5	0.2	0.1	0.1	0.7	1.9	3.5	1.7	1.1	0.7	0.7	0.6	14.0	5.5- 6.4
D 14.5-16.6	0.3	0.2	0.3	0.2	0.2	0.1	0.0	0.0	0.4	1.6	3.1	1.2	0.7	0.4	0.4	0.4	9.5	6.5- 7.4
16.8-18.8	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.3	1.2	2.8	1.3	0.6	0.3	0.4	0.4	8.1	7.5- 8.4
M 19.0-21.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3	1.1	2.7	1.2	0.6	0.2	0.2	0.3	7.0	8.5- 9.4
I 21.3-23.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	2.1	0.9	0.4	0.1	0.1	0.1	4.6	9.5-10.4
L 23.5-25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	1.7	0.8	0.3	0.1	0.1	0.1	3.7	10.5-11.4
E 25.7-27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0	0.4	0.2	0.0	0.0	0.0	1.8	11.5-12.4
S 28.0-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.4	0.1	0.0	0.0	0.0	1.5	12.5-13.4
/ 30.2-32.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	0.3	0.1	0.0	0.0	0.0	1.3	13.5-14.4
H 32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.2	0.1	0.0	0.0	0.0	0.8	14.5-15.4
O 34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.3	15.5-16.4
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	16.5-17.4
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
CALM																	1.9	CALM
TOTAL	4.2	2.6	3.7	3.3	4.0	2.6	1.6	1.0	4.8	11.5	25.2	12.9	8.0	3.9	4.3	4.4	99.9	TOTAL
AV SPD (MPH)	9.2	8.5	8.7	8.3	7.6	6.9	6.5	6.7	10.1	13.0	15.7	14.1	11.9	10.3	10.7	10.5	9.9	AV SPD (MPH)
AV SPD (M/S)	4.1	3.8	3.9	3.7	3.4	3.1	2.9	3.0	4.5	5.8	7.0	6.3	5.3	4.6	4.8	4.7	4.4	AV SPD (M/S)

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Figure IV - 2
Annual Wind Rose
GREAT FALLS NWS AIRPORT— CASCADE COUNTY
(1965 - 1978)





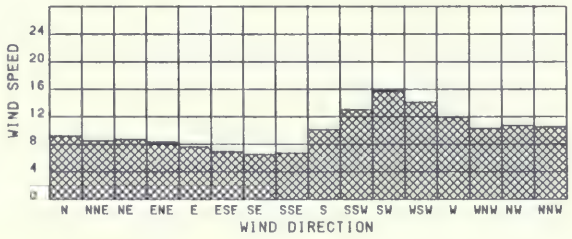


Table IV - 22

Coefficients of Weibull Distribution

CASCADE COUNTY - GREAT FALLS NWS AIRPORT

01/01/65 - 12/31/78

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.3360	1.9960
FEBRUARY	7.4020	2.1990
MARCH	7.0660	2.0710
APRIL	6.5430	2.2810
MAY	6.2960	2.3180
JUNE	5.9260	2.3470
JULY	5.6600	2.4930
AUGUST	5.7710	2.4570
SEPTEMBER	6.1400	2.5050
OCTOBER	7.1040	2.5040
NOVEMBER	7.2100	2.1150
DECEMBER	7.8730	2.1590
YEAR	6.7150	2.2100

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

SALEM

CASCADE COUNTY

The Salem site is located 1 mile south of the Missouri River and about 15 miles east of Great Falls at 47 34 22 N and 111 02 34 W (Site No. 17 on Map II-1). Elevation at the site is 3,250 feet. The site was established by the Montana Power Company to measure background meteorological and air quality conditions for the company's proposed Salem project.

Wind data were collected from May 1980 through March 1984. Data from May 1, 1980 through October 31, 1981, were available for analysis for the first edition of the *Atlas*. The data set contains hourly averages of:

- Wind speed and direction at 10, 30, and 100 meters above ground level;
- Standard deviation of wind direction at 100 meters;
- Average vertical wind direction at 100 meters;
- Temperature at 10, 30, and 100 meters;
- Stability based on actual lapse rate of temperature with height.

The data were recorded by a data acquisition system that scanned each parameter every 30 seconds. All the electronic meteorological sensors were manufactured by Met One, Inc., and were mounted on a 100-meter tower. Winds were monitored long enough to adequately represent the wind resource at this location. The data are representative of the wind resource in the Great Falls area at relatively high and exposed sites.

Data recovery at the 10-meter level was excellent, ranging from 94.5 percent in January to 99.4 percent in April. Overall data recovery was 97.9 percent. Average annual wind speed was 10.2 miles per hour. Average monthly wind speed values ranged from 8.0 miles per hour in January to 14.3 miles per hour in December. Average annual wind power was 139.7 watts/m² and ranged from 50.5 watts/m² in August to 457.8 watts/m² in December.

At the 30-meter level, average annual wind speed was 11.9 miles per hour, with monthly average speeds ranging from 9.1 miles per hour in August to 16.3 miles per hour in December. Average annual wind power at this level was 214.6 watts/m², with a low monthly average of 79.2 watts/m² in August and a high monthly average of 671.5 watts/m² in December.

At the 100-meter level, wind speeds averaged 14.5 miles per hour on an annual basis, with an August low of 10.7 miles per hour and a November high of 20.8 miles per hour. Average annual wind power at this level was 379.4 watts/m², with average monthly values ranging from 127.9 watts/m² in August to 1041.2 watts/m² in December.

Further analysis of this site is presented in Chapter V.

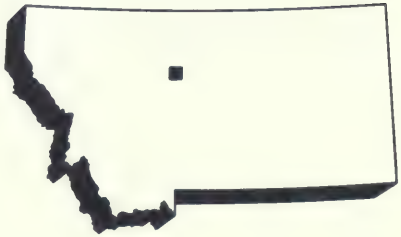


Table IV - 23

Monthly Wind Speed Distribution

CASCADE COUNTY - SALEM

05/01/80 - 10/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM	0.6	0.0	0.4	0.3	0.2	0.2	0.6	0.0	0.0	0.0	0.0	0.5	0.2	CALM	
1.3- 2.2	14.2	5.7	10.0	7.0	6.7	3.9	6.1	6.7	7.1	6.2	4.9	8.1	6.9	0.6- 1.5	S
S 3.6- 5.6	21.5	14.3	23.2	11.5	24.3	17.7	22.1	28.5	22.8	14.2	10.6	21.1	20.1	1.6- 2.5	P
P 5.8- 7.8	17.6	12.8	20.8	9.6	20.1	20.6	23.2	26.9	18.7	15.9	14.1	15.2	19.0	2.6- 3.5	E
E 8.1-10.1	18.3	12.0	17.1	12.7	16.0	17.0	16.7	16.3	14.8	18.1	11.3	7.0	15.4	3.6- 4.5	E
E 10.3-12.3	12.1	9.0	9.6	12.0	11.3	12.1	9.3	8.5	9.9	13.2	11.0	3.8	10.3	4.6- 5.5	D
D 12.5-14.5	6.3	5.4	5.9	10.1	8.8	7.6	5.9	5.0	6.6	9.9	9.7	3.4	7.1	5.6- 6.5	
14.8-16.8	4.3	5.4	1.9	9.1	5.8	7.7	6.4	2.9	5.9	5.9	6.6	2.7	5.5	6.6- 7.5	M
M 17.0-19.0	2.2	5.9	4.9	7.7	3.2	6.3	3.2	1.8	4.0	3.8	6.1	3.1	4.1	7.6- 8.5	/
P 19.2-25.7	2.6	18.3	6.1	12.0	3.3	5.3	5.7	3.1	8.0	10.2	16.2	15.4	7.8	8.6-11.5	S
H 25.9-30.2	0.3	6.5	0.1	5.9	0.4	0.8	0.7	0.2	2.1	1.9	6.3	9.5	2.2	11.6-13.5	E
30.4-34.7	0.0	2.7	0.0	2.1	0.0	0.6	0.1	0.1	0.1	0.6	2.3	5.4	0.9	13.6-15.5	C
34.9-39.1	0.0	1.8	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.8	3.7	0.4	15.6-17.5	
>39.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.9	0.1	>17.5	
AVERAGE SPEED (MPH)	8.0	13.8	8.6	13.0	8.7	10.1	9.0	7.8	9.8	10.9	13.6	14.3	10.2		
AVERAGE SPEED (M/SEC)	3.6	6.2	3.8	5.8	3.9	4.5	4.0	3.5	4.4	4.9	6.1	6.4	4.6		
AVERAGE WIND POWER (WATTS/M**2)	59.4	325.7	77.9	234.6	67.5	104.5	79.9	50.5	110.6	140.8	278.3	457.8	139.7		
PERCENT DATA RECOVERY	94.5	99.1	98.4	99.4	96.8	98.9	99.3	98.6	97.4	96.0	98.5	99.2	97.9		

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 12927
PERCENTAGE DATA RECOVERY = 97.9

SOURCE: GEORESEARCH, INC.

Table IV - 24

Monthly Average Wind Speed and Wind Power Density (30 Meters)

CASCADE COUNTY - SALEM

05/01/80 - 10/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
AVERAGE SPEED (MPH)	9.4	16.1	9.6	15.0	10.2	12.0	10.7	9.1	11.4	12.9	16.2	16.3	11.9
AVERAGE SPEED (M/SEC)	4.2	7.2	4.3	6.7	4.6	5.4	4.8	4.1	5.1	5.8	7.2	7.3	5.3
AVERAGE WIND POWER (WATTS/M**2)	95.0	489.0	108.3	347.9	106.5	166.5	125.7	79.2	171.1	226.2	432.7	671.5	214.6
PERCENT DATA RECOVERY	97.6	99.1	95.2	99.4	96.8	97.2	99.3	98.6	97.4	96.0	98.5	99.2	97.7

SOURCE: GEORESEARCH, INC.

Table IV - 25

Monthly Average Wind Speed and Wind Power Density (100 Meters)

CASCADE COUNTY - SALEM

05/01/80 - 10/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
AVERAGE SPEED (MPH)	12.7	20.3	12.1	18.1	11.8	14.6	12.7	10.7	13.8	16.4	20.8	17.5	14.5
AVERAGE SPEED (M/SEC)	5.7	9.1	5.4	8.1	5.3	6.5	5.7	4.8	6.2	7.3	9.3	7.8	6.5
AVERAGE WIND POWER (WATTS/M*2)	240.0	958.4	223.8	583.1	169.1	292.8	216.6	127.9	306.2	441.9	857.1	1041.2	379.4
PERCENT DATA RECOVERY	97.6	99.1	98.4	99.3	96.8	97.2	99.3	98.6	97.4	96.0	98.5	86.1	97.0

SOURCE: GEORESEARCH, INC.

HIGHWOOD BENCH

CHOUTEAU COUNTY

The Highwood Bench site is located approximately 10 miles northwest of Highwood at 47 41 01 N and 110 54 02 W (Site No. 18 on Map II-1). Highwood Bench is an extensive flat, sloping southeastward up to the Highwood Mountains. The monitoring site is near the top of a gentle rise where wind flow is unobstructed. Elevation at the site is 3,325 feet. This site was established by the Bureau of Reclamation as part of its Northern Great Plains Wind Energy Study. The Department of Natural Resources and Conservation assumed responsibility for the monitoring site in October 1982.

Collection of wind data began on June 5, 1981 and continued through June 17, 1983. Data from the wind sensors were recorded continuously on cassette tape at the site. These tapes were processed further by computer to yield hourly averages of wind speed, wind direction, the average cube of the hourly speed, and standard deviation of the hourly speed. In addition, the maximum and minimum instantaneous values of wind speed during each hour were recorded. Anemometer height was 10 meters above ground level.

Data recovery was poor to good, ranging from 38.7 percent in August to 81.5 percent in December. Overall data recovery based on data provided to DNRC was 68.0 percent. Actual data recovery, as reported by the Bureau of Reclamation in hard copy, was higher; however, numerous data tapes from the period between July 1982 and May 1983 were not available for re-analysis. The missing data do not appear to have greatly influenced monthly and yearly averages. When the site was decommissioned, the tail of the wind vane was found to be badly bent downwards. Thus, the wind direction data is questionable, especially after the tail on the wind vane was bent, whenever that was.

Winds were monitored long enough to adequately represent the wind resource at the site. The data are representative of a limited area on the northwest and north-facing slopes of the Highwood Mountains.

Average annual wind speed at this site was 10.5 miles per hour. Average monthly wind speed varied from 7.4 miles per hour in August to 12.8 miles per hour in December.

Average monthly wind power ranged from 26.9 watts/m^2 in August to 224.9 watts/m^2 in December. Average annual wind power was 122.6 watts/m^2.

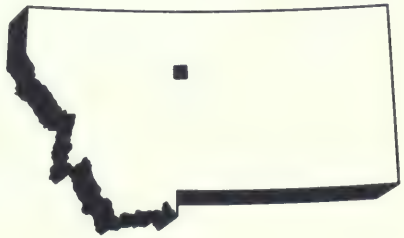


Table IV - 26

Monthly Wind Speed Distribution

CHOUTEAU COUNTY - HIGHWOOD BENCH

06/05/81 - 06/17/83

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	SPEED (MPH)
CALM	0.4	1.6	4.2	0.0	0.0	0.6	18.5	0.0	0.0	0.0	0.0	0.6	2.4	CALM
0.1-1.0	2.1	1.4	0.7	0.0	0.2	1.5	0.3	0.0	0.2	0.3	0.5	0.6	0.7	0.1- 0.4
1.1-2.0	4.6	3.0	1.3	1.2	0.5	1.2	1.2	0.5	0.8	1.0	1.4	3.5	1.7	0.5- 0.9
2.1-3.0	3.0	3.0	3.2	1.8	1.9	2.0	2.4	1.7	2.1	1.8	2.6	3.6	2.4	1.0- 1.3
3.1-4.0	6.2	5.8	5.3	4.2	3.7	4.2	6.4	6.6	6.2	3.5	4.4	5.0	5.1	1.4- 1.8
4.1-5.0	7.1	5.3	7.0	4.8	5.5	4.6	7.0	11.1	6.9	3.3	3.3	4.8	5.7	1.9- 2.2
5.1-6.0	7.9	5.9	6.1	7.4	6.8	8.3	8.6	17.0	10.0	7.0	5.0	4.5	7.5	2.3- 2.7
6.1-7.0	7.7	4.4	7.6	6.4	5.9	7.2	6.7	12.0	7.9	6.3	5.9	4.9	6.7	2.8- 3.1
7.1-8.0	7.8	7.2	10.2	6.8	6.9	8.7	8.0	14.4	9.3	8.7	6.1	5.2	8.0	3.2- 3.6
8.1-9.0	5.1	4.5	6.8	7.1	7.2	7.5	5.8	9.9	9.4	9.1	5.3	4.7	6.8	3.7- 4.0
9.1-10.0	5.5	4.3	9.5	7.1	10.7	10.4	6.9	11.3	10.7	11.6	6.4	4.7	8.1	4.1- 4.5
10.1-11.0	3.3	5.4	6.7	5.9	7.6	9.0	6.2	8.3	9.8	7.5	5.2	4.5	6.6	4.6- 4.9
11.1-12.0	4.1	7.0	6.7	6.0	10.5	7.9	5.2	3.3	6.8	9.3	8.5	3.2	6.6	5.0- 5.4
12.1-13.0	3.4	5.2	3.3	6.4	5.8	4.8	2.7	1.7	4.1	5.0	6.7	4.1	4.6	5.5- 5.8
13.1-14.0	4.1	6.1	1.9	5.4	6.7	4.4	1.9	0.7	4.2	3.8	8.6	5.4	4.5	5.9- 6.3
14.1-15.0	2.9	4.8	2.2	4.8	3.8	2.5	1.7	0.3	3.3	3.1	5.1	3.3	3.3	6.4- 6.7
15.1-16.0	1.5	3.5	2.3	3.7	2.7	2.1	1.4	0.3	1.6	2.7	4.5	4.5	2.7	6.8- 7.2
16.1-17.0	2.3	3.0	2.1	3.6	3.1	3.0	1.0	0.0	2.2	2.6	4.5	6.4	3.0	7.3- 7.6
17.1-18.0	1.9	1.9	1.4	2.9	1.8	2.1	1.1	0.2	0.8	1.6	2.6	3.0	1.9	7.7- 8.0
18.1-19.0	1.8	3.0	2.2	2.9	1.7	1.8	1.5	0.2	1.4	1.5	1.7	3.9	2.1	8.1- 8.5
19.1-20.0	2.6	2.5	1.7	2.1	2.1	1.3	0.9	0.0	0.4	1.1	2.6	2.0	1.6	8.6- 8.9
20.1-25.0	7.5	8.1	4.0	6.4	4.1	4.5	3.5	0.3	1.5	6.4	7.0	11.3	5.6	9.0-11.2
25.1-30.0	4.6	2.6	3.0	2.3	0.6	0.4	1.0	0.0	0.5	2.3	1.9	3.9	2.0	11.3-13.4
30.1-35.0	1.6	0.5	0.6	0.8	0.1	0.1	0.0	0.0	0.1	0.5	0.0	2.0	0.6	13.5-15.6
35.1-40.0	0.4	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	15.7-17.9
>40.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	>17.9
AVERAGE SPEED (MPH)	11.0	11.2	9.8	11.6	10.7	10.0	7.5	7.4	9.2	11.0	11.7	12.8	10.5	
AVERAGE SPEED (M/SEC)	4.9	5.0	4.4	5.2	4.8	4.5	3.4	3.3	4.1	4.9	5.2	5.7	4.7	
AVERAGE WIND POWER (WATTS/M**2)	194.9	153.2	117.2	144.9	96.1	85.8	62.3	26.9	63.0	121.2	135.5	224.9	122.6	
PERCENT DATA RECOVERY	62.7	67.9	60.9	90.6	65.1	65.0	78.2	38.7	71.0	71.0	64.4	81.5	68.0	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 12120
PERCENTAGE DATA RECOVERY = 68.0

SOURCE: GEORESEARCH, INC.

MILES CITY FAA AIRPORT

CUSTER COUNTY

The Miles City Airport is located approximately 2 miles northwest of Miles City at 46 25 48 N and 105 52 12 W (Site No. 19 on Map II-1). Elevation at the airport is 2,631 feet. Meteorological data have been collected at this site for many years by the Federal Aviation Administration.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in recording interval, the data set was split into two parts for analysis: January 1, 1948, through December 31, 1964; and January 1, 1965, through December 31, 1978. Data from the latter period only were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Miles City consists of summaries of observations made every third hour from January 1, 1965, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 12.2 meters. The site is representative of much of the high ground along the Yellowstone River in southeastern Montana.

Average monthly wind speeds ranged from 9.8 miles per hour duringJuly, August, and November to 11.9 miles per hour in April. Average annual wind speed was 10.5 miles per hour.

Average monthly wind power ranged from 91.0 watts/m² in July and August to 163.0 watts/m² in April. Average annual wind power was 116.0 watts/m².

Table IV - 27

Monthly Wind Speed Distribution

CUSTER COUNTY - MILES CITY FAA AIRPORT

01/01/65 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	6.5	6.7	5.6	4.1	4.8	6.0	6.6	5.6	6.0	4.9	6.8	5.4	5.7	CALM (<0.5)
1.1- 3.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.2	0.1	0.1	0.1	0.5- 1.4
3.4- 5.4	6.3	5.3	5.4	3.1	3.9	5.2	4.9	4.9	5.6	6.0	5.6	5.8	5.2	1.5- 2.4 S
S 5.6- 7.6	19.3	20.5	18.5	15.2	16.4	18.9	20.4	22.6	20.4	21.3	20.7	20.7	19.6	2.5- 3.4 P
P 7.8- 9.8	24.1	23.9	21.7	20.9	21.0	22.3	25.7	25.0	23.9	24.8	25.6	24.8	23.6	3.5- 4.4 E
E 10.1-12.1	15.8	15.9	14.8	17.0	16.2	15.5	16.1	16.2	15.9	15.2	16.0	15.2	15.8	4.5- 5.4 E
E 12.3-14.3	9.3	9.6	10.4	10.5	11.0	11.3	9.8	9.8	9.0	9.0	8.9	9.6	9.9	5.5- 6.4 D
D 14.5-16.6	5.4	5.7	6.4	6.9	7.3	6.1	5.9	5.3	5.7	5.2	5.3	5.6	5.9	6.5- 7.4
16.8-18.8	5.8	5.3	6.7	9.5	9.2	7.5	5.8	5.2	6.3	5.9	4.7	5.9	6.5	7.5- 8.4 M
M 19.0-21.0	3.4	3.4	4.8	5.9	4.9	4.0	2.4	2.2	3.5	3.1	2.5	3.3	3.6	8.5- 9.4 E
I 21.3-23.3	2.3	1.8	2.7	3.4	2.9	2.2	1.1	1.5	1.9	2.2	1.8	2.0	2.2	9.5-10.4 T
L 23.5-25.5	0.6	0.4	1.0	1.2	0.7	0.3	0.3	0.4	0.7	0.8	0.7	0.6	0.6	10.5-11.4 E
E 25.7-27.7	0.4	0.3	0.5	0.6	0.6	0.2	0.3	0.4	0.5	0.6	0.3	0.4	0.4	11.5-12.4 R
S 28.0-30.0	0.5	0.4	0.7	0.9	0.8	0.3	0.2	0.3	0.2	0.5	0.6	0.4	0.5	12.5-13.4 S
/ 30.2-32.2	0.1	0.3	0.4	0.3	0.1	0.0	0.2	0.2	0.1	0.2	0.3	0.1	0.2	13.5-14.4 /
H 32.4-34.4	0.1	0.1	0.2	0.2	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	14.5-15.4 S
O 34.7-36.7	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	10.1	10.1	11.0	11.9	11.4	10.5	9.8	9.8	10.3	10.3	9.8	10.1	10.5	
AVERAGE SPEED (M/SEC)	4.5	4.5	4.9	5.3	5.1	4.7	4.4	4.4	4.6	4.6	4.4	4.5	4.7	
AVERAGE WIND POWER (WATTS/M**2)	114.0	111.0	138.0	163.0	139.0	106.0	91.0	91.0	108.0	113.0	106.0	109.0	116.0	

ANEMOMETER HEIGHT = 40.0 FEET = 12.2 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

SCOBEY BORDER

DANIELS COUNTY

The Scobey Border air monitoring site is located on the United States-Canadian border 14 miles north of Scobey at 49 00 00 N and 105 24 00 W (Site No. 20 on Map II-1). Elevation at the site is 2,467 feet. The site was established by the Montana Air Quality Bureau as part of the Poplar River Study to measure particulate and sulfur dioxide concentrations, and to collect data on several meteorological parameters.

Wind data have been collected at the station since March 2, 1977. Data through April 26, 1982, were available for analysis. The data set contains hourly averages for wind speed and wind direction, which until 1980 were manually reduced from stripchart records. In 1980, a data acquisition system that scanned each parameter several times per minute was installed. A Climatronics electronic anemometer and wind vane is used to monitor winds at the site. Anemometer height is 4 meters. Winds have been monitored long enough at this site to represent the wind resource of the northeastern corner of Montana.

Overall data recovery was 78.2 percent, varying from 49.9 percent in June to 99.2 percent in December. The data indicate significant periods of calm during the winter months. This is probably due, in part, to freezing of the anemometer cups. Consequently, wind speeds recorded during the winter may be lower than they actually were. The data otherwise appear to be accurate.

Average annual wind speed at the site was 7.2 miles per hour. Average monthly wind speeds varied from 4.5 miles per hour in September to 8.8 miles per hour in April.

Average monthly wind power ranged from 4.1 watts/m^2 in September to 156.2 watts/m^2 in February. Average annual wind power was 85.3 watts/m^2.

Table IV - 28

Monthly Wind Speed Distribution

DANIELS COUNTY - SCOBEY BORDER

03/02/77 - 04/26/82

SPEED (MILES/HOUR)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	4.8	3.2	2.1	1.8	1.1	2.6	1.8	0.8	0.4	0.9	2.2	8.4	2.7
0.1-1.0	3.0	2.6	3.8	2.1	2.2	4.3	6.7	10.1	14.0	7.2	6.4	1.8	5.0
1.1-2.0	9.1	4.9	7.0	6.1	5.7	7.3	11.0	13.4	21.9	13.7	11.8	6.7	9.5
2.1-3.0	10.2	7.5	9.3	7.5	7.5	9.8	15.9	14.3	13.6	13.4	12.9	10.7	10.8
3.1-4.0	8.9	6.7	8.6	6.7	7.7	9.9	12.5	10.8	9.0	9.0	9.8	8.3	8.8
4.1-5.0	8.1	8.8	7.6	7.7	7.1	10.8	13.3	11.0	8.3	8.2	9.5	9.8	9.0
5.1-6.0	7.3	6.3	6.1	5.8	7.6	6.9	6.7	7.1	5.1	6.5	7.1	5.7	6.5
6.1-7.0	7.3	8.8	6.3	6.3	7.2	7.8	7.3	7.4	5.7	6.8	6.2	7.5	7.0
7.1-8.0	5.3	5.8	5.8	6.2	6.7	6.2	4.7	4.3	3.3	5.0	4.9	4.3	5.2
8.1-9.0	5.4	6.2	5.8	6.1	7.2	6.0	3.9	4.5	3.5	3.9	4.8	4.6	5.2
9.1-10.0	3.8	5.1	4.2	5.0	5.9	5.1	3.4	3.3	2.5	3.5	3.6	2.6	4.0
10.1-11.0	3.5	5.3	4.7	4.8	5.7	3.6	2.5	3.0	2.9	3.4	3.7	3.7	4.0
11.1-12.0	2.6	3.2	3.2	4.4	4.0	3.2	2.1	2.2	2.2	1.7	1.9	2.5	2.8
12.1-13.0	2.9	3.9	3.6	4.0	4.7	2.3	1.6	2.0	1.8	2.8	2.5	3.0	3.0
13.1-14.0	2.3	2.6	2.9	3.8	3.8	2.1	1.0	1.5	1.0	2.0	1.7	2.1	2.3
14.1-15.0	1.9	2.3	2.9	4.1	3.1	2.1	1.0	1.2	1.3	2.3	1.5	2.0	2.2
15.1-16.0	1.6	2.4	1.9	2.8	2.0	1.7	0.7	0.7	0.9	1.3	1.4	2.1	1.7
16.1-17.0	1.4	1.6	2.1	2.6	2.3	1.4	0.8	0.4	0.5	1.5	1.5	1.8	1.6
17.1-18.0	1.6	1.7	2.5	2.4	1.9	1.4	0.8	0.6	0.6	1.2	1.0	1.8	1.6
18.1-19.0	0.8	1.5	2.2	2.3	1.6	1.0	0.2	0.5	0.5	0.8	1.0	1.3	1.2
19.1-20.0	1.6	1.8	1.6	1.7	1.4	0.9	0.5	0.6	0.3	0.9	0.6	1.8	1.2
20.1-25.0	5.1	4.4	4.1	4.5	2.7	2.4	1.3	0.2	0.7	3.2	2.6	4.6	3.2
25.1-30.0	1.0	2.1	1.0	0.9	0.4	1.0	0.3	0.1	0.0	0.7	0.6	2.1	0.9
30.1-35.0	0.3	1.3	0.4	0.1	0.3	0.2	0.0	0.0	0.0	0.1	0.2	0.6	0.3
35.1-40.0	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.3	0.1	0.1
>40.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
AVERAGE SPEED (MPH)	7.4	8.7	8.2	8.8	8.2	6.9	5.2	5.0	4.5	6.4	6.8	7.7	7.2
AVERAGE SPEED (M/SEC)	3.3	3.9	3.6	3.9	3.7	3.1	2.3	2.3	2.0	2.9	3.0	3.4	3.2
AVERAGE WIND POWER (WATTS/M**2)	80.5	156.2	108.1	135.9	89.4	89.3	33.3	15.8	4.1	54.1	72.1	116.6	85.3
PERCENT DATA RECOVERY	89.4	84.9	88.3	82.2	73.7	49.9	61.6	58.3	62.3	91.6	94.5	99.2	78.2

SPEED (MILES/HOUR)	
CALM	
0.1- 0.4	
0.5- 0.9	
1.0- 1.3	
1.4- 1.8	
1.9- 2.2	
2.3- 2.7	
2.8- 3.1	
3.2- 3.6	
3.7- 4.0	
4.1- 4.5	
4.6- 4.9	
5.0- 5.4	
5.5- 5.8	
5.9- 6.3	
6.4- 6.7	
6.8- 7.2	
7.3- 7.6	
7.7- 8.0	
8.1- 8.5	
8.6- 8.9	
9.0-11.2	
11.3-13.4	
13.5-15.6	
15.7-17.9	
>17.9	

SPEED / HOUR

MEASURED AT 4 METERS = 13 FEET

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
NUMBER OF OBSERVATIONS = 35329
PERCENTAGE DATA RECOVERY = 78.2

SOURCE: GEORESEARCH, INC.

SCOBEY HANRAHAN

DANIELS COUNTY

The Scobey Hanrahan site is located approximately 14 miles northeast of Scobey at 48 53 47 N and 105 17 05 W (Site No. 21 on Map II-1). Elevation at the site is 2,781 feet. This monitoring station was established by the Montana Air Quality Bureau to measure sulfur dioxide concentrations in the air and various meteorological parameters as part of the Poplar River Study.

The land to the south of the station is a flat, elevated bench used primarily for dryland grain farming. To the north and west, the land drops away into the Poplar River valley. Relief in the area is 300 to 400 feet. Access to the site is provided by gravel roads maintained by the county. During the winter, access occasionally is difficult because of blowing snow.

Land in the area is, for the most part, privately owned. However, a considerable amount of state-owned land lies west and north of the station. Most of this land is leased to private landowners for agricultural uses.

The area is served by the Sheridan Electric Cooperative and by Montana-Dakota Utilities Company. A 57 kV transmission line runs approximately 10 miles south of the site. A microwave relay tower sits on a hill approximately 1 mile northeast of the site. There is no commercial air traffic in the area. The station, however, is located near the northern edge of the Williston MOA (Military Operations Area), so there are occasional military training exercises between 4,000 and 18,000 feet MSL.

Wind speed data have been gathered at the site since April 1, 1981. Data through March 31, 1982, were available for analysis. The data set contains hourly averages of wind speed and wind direction recorded by a data acquisition system that scans each parameter several times per minute. Wind data at the site are recorded by a Climatronics electronic anemometer and wind vane on a 10-meter tower. Winds have been monitored long enough at this site to give a good indication of the wind resource at this location, which is representative of exposed sites in the northeastern corner of Montana.

The data set is relatively complete, with data recovery ranging from 61.6 percent in March to 98.7 percent in February. Data recovery was 88.9 percent for the entire period of analysis.

Average monthly wind speeds ranged from 7.2 miles per hour in November to 15.6 miles per hour in May. Average annual wind speed was 11.6 miles per hour.

Average annual wind power was 178.3 watts/m^2. Average monthly wind power ranged from 59.8 watts/m^2 in November to 378.0 watts/m^2 in March.

Average seasonal wind speeds were 10.4 miles per hour in summer, 10.6 miles per hour in autumn, 12.4 miles per hour in winter, and 13.1 miles per hour in spring. The highest average wind speeds occurred from noon to mid-afternoon during all seasons except winter, when they occurred during the early evening. The lowest average wind speeds occurred from after midnight to dawn in spring, before dawn in summer and autumn, and during mid-morning in winter. The diurnal range of average wind speeds was greatest in spring and least in winter.

Winds were most common from the west-southwest through northwest. Winds from the north-northeast through east-northeast were least common. By direction, average wind speeds varied from 8.5 miles per hour for winds from the south-southwest to 13.9 miles per hour for northwesterly winds.

Table IV - 29

Monthly Wind Speed Distribution

DANIELS COUNTY - SCOBEY HANRAHAN

04/01/81 - 03/31/82

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	0.1	1.2	1.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	19.7	1.5	2.3
0.1-1.0	0.0	1.2	0.0	0.4	0.0	0.2	0.5	0.0	0.0	0.0	0.3	0.1	0.2
1.1-2.0	0.8	1.4	1.5	1.8	0.0	0.9	0.2	0.7	0.4	0.2	1.4	2.1	0.9
2.1-3.0	2.3	1.5	2.8	5.0	0.3	3.0	1.4	3.9	7.3	0.8	5.1	8.5	3.6
3.1-4.0	1.1	1.1	0.7	4.4	0.2	4.8	2.0	2.4	0.6	0.5	0.7	5.2	2.0
4.1-5.0	3.8	5.0	6.6	7.9	1.8	5.4	2.2	7.9	5.5	2.3	11.3	11.0	5.9
5.1-6.0	1.2	0.9	1.7	7.9	2.7	6.1	9.8	8.2	9.7	2.9	0.9	1.9	4.5
6.1-7.0	7.0	6.9	7.2	10.2	5.1	5.0	15.1	15.5	10.0	7.4	14.4	10.4	9.7
7.1-8.0	2.2	1.4	1.7	7.0	3.5	6.3	0.9	1.0	0.4	0.3	0.9	1.8	2.2
8.1-9.0	5.9	6.3	6.6	9.5	5.9	7.2	18.4	18.0	13.1	12.1	12.5	10.4	10.6
9.1-10.0	5.5	2.7	2.0	8.1	3.6	5.8	0.6	0.7	0.0	0.0	0.1	0.4	2.4
10.1-11.0	3.3	8.1	6.8	5.8	5.6	6.7	10.3	13.8	10.1	14.5	9.3	6.7	8.4
11.1-12.0	3.8	3.3	3.7	4.0	5.7	6.9	2.5	0.6	0.4	0.5	1.9	4.6	3.1
12.1-13.0	10.4	9.5	7.2	3.9	6.8	8.0	10.3	9.7	11.4	11.1	8.1	7.9	8.7
13.1-14.0	2.5	4.1	2.0	3.7	5.6	6.1	1.4	1.1	0.4	1.0	1.3	1.2	2.5
14.1-15.0	8.2	11.0	6.1	3.0	7.4	4.8	8.1	5.5	9.0	12.9	5.3	6.5	7.3
15.1-16.0	9.3	10.1	5.2	1.9	3.5	3.2	2.3	2.0	3.0	2.3	1.3	6.4	4.2
16.1-17.0	2.6	1.8	2.8	2.1	4.8	4.1	0.5	0.7	0.0	0.6	0.1	1.2	1.7
17.1-18.0	2.5	1.8	1.3	2.1	4.7	3.2	5.6	5.5	4.7	11.6	1.1	0.9	3.8
18.1-19.0	5.0	5.6	3.9	0.7	2.6	3.0	0.3	0.0	0.0	0.0	1.1	1.5	1.9
19.1-20.0	5.3	3.5	6.3	1.6	4.7	2.0	2.7	0.7	3.3	8.5	0.9	2.1	3.4
20.1-25.0	9.1	8.1	11.8	4.1	15.1	5.2	4.4	1.4	6.3	6.6	1.7	3.1	6.3
25.1-30.0	4.8	2.9	4.6	1.9	6.9	0.7	0.3	0.7	3.8	3.5	0.7	3.6	2.9
30.1-35.0	1.5	0.6	3.7	0.7	3.0	0.7	0.0	0.0	0.7	0.6	0.0	1.0	1.0
35.1-40.0	1.8	0.0	0.9	0.3	0.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4
>40.0	0.1	0.0	1.1	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1
AVERAGE SPEED (MPH)	14.3	12.9	14.4	9.7	15.6	11.3	10.6	9.4	11.3	13.6	7.2	9.9	11.6
AVERAGE SPEED (M/SEC)	6.4	5.8	6.4	4.3	7.0	5.1	4.8	4.2	5.1	6.1	3.2	4.4	5.2
AVERAGE WIND POWER (WATTS/M**2)	302.0	199.0	378.0	127.9	323.0	144.4	112.5	73.1	157.4	202.1	59.8	143.3	178.3
PERCENT DATA RECOVERY	98.5	98.7	61.6	93.8	89.3	74.9	86.2	95.4	97.6	83.6	97.5	90.5	88.9

SPEED (MPH)	MEAN
CALM	CALM
0.1-1.0	0.1- 0.4
1.1-2.0	0.5- 0.9
2.1-3.0	1.0- 1.3
3.1-4.0	1.4- 1.8
4.1-5.0	1.9- 2.2
5.1-6.0	2.3- 2.7
6.1-7.0	2.8- 3.1
7.1-8.0	3.2- 3.6
8.1-9.0	3.7- 4.0
9.1-10.0	4.1- 4.5
10.1-11.0	4.6- 4.9
11.1-12.0	5.0- 5.4
12.1-13.0	5.5- 5.8
13.1-14.0	5.9- 6.3
14.1-15.0	6.4- 6.7
15.1-16.0	6.8- 7.2
16.1-17.0	7.3- 7.6
17.1-18.0	7.7- 8.0
18.1-19.0	8.1- 8.5
19.1-20.0	8.6- 8.9
20.1-25.0	9,0-11.2
25.1-30.0	11.3-13.4
30.1-35.0	13.5-15.6
35.1-40.0	15.7-17.9
>40.0	>17.9

SPEED (MPH) MEAN

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 7783
PERCENTAGE DATA RECOVERY = 88.9

SOURCE: GEORESEARCH, INC.

Table IV - 30

Percentage Frequency Summary For Wind Speed

DANIELS COUNTY - SCOBEY HANRAHAN (WINTER)

04/01/81 - 03/31/82

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (M/SEC)															
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	1.2	0.0	5.8	9.3	9.3	12.8	10.5	10.5	19.8	1.2	4.7	10.5	2.3	1.2	1.2	0.0	12.4	5.5
	2	0.0	0.0	8.1	5.8	10.5	15.1	12.8	10.5	8.1	7.0	8.1	9.3	3.5	1.2	0.0	0.0	12.4	5.6
	3	1.2	1.2	8.2	9.4	9.4	9.4	17.6	7.1	12.9	1.2	10.6	8.2	3.5	0.0	0.0	0.0	11.9	5.3
	4	0.0	2.4	9.4	8.2	8.2	14.1	8.2	11.8	15.3	1.2	9.4	9.4	2.4	0.0	0.0	0.0	11.7	5.2
	5	1.2	2.4	9.4	5.9	8.2	14.1	10.6	11.8	12.9	4.7	11.8	2.4	4.7	0.0	0.0	0.0	11.7	5.2
	6	1.2	2.4	7.1	10.6	7.1	9.4	11.8	11.8	17.6	3.5	11.8	1.2	4.7	0.0	0.0	0.0	11.7	5.2
	7	1.2	4.7	8.2	5.9	11.8	8.2	12.9	10.6	15.3	2.4	8.2	4.7	4.7	0.0	1.2	0.0	11.7	5.2
	8	2.4	3.5	8.2	7.1	14.1	8.2	5.9	9.4	20.0	4.7	4.7	5.9	3.5	2.4	0.0	0.0	11.7	5.2
H	9	2.4	5.9	7.1	7.1	7.1	11.8	7.1	16.5	16.5	4.7	2.4	5.9	4.7	1.2	0.0	0.0	11.6	5.2
O	10	1.2	4.7	9.3	5.8	7.0	9.3	9.3	18.6	19.8	1.2	5.8	2.3	4.7	1.2	0.0	0.0	11.4	5.1
	11	2.4	2.4	7.1	8.2	9.4	7.1	10.6	15.3	20.0	2.4	5.9	2.4	4.7	2.4	0.0	0.0	11.9	5.3
U	12	2.3	0.0	5.8	9.3	9.3	10.5	11.6	11.6	14.0	3.5	5.8	8.1	4.7	2.3	1.2	0.0	12.7	5.7
	13	2.3	3.5	3.5	8.1	11.6	8.1	5.8	15.1	19.8	1.2	4.7	7.0	7.0	2.3	0.0	0.0	12.9	5.7
R	14	1.1	1.1	5.7	9.1	12.5	12.5	10.2	8.0	12.5	2.3	8.0	8.0	5.7	2.3	1.1	0.0	12.9	5.8
	15	0.0	3.4	4.5	8.0	10.2	10.2	8.0	11.4	19.3	3.4	5.7	9.1	3.4	2.3	1.1	0.0	13.1	5.9
	16	0.0	0.0	5.7	11.4	11.4	5.7	10.2	14.8	17.0	2.3	6.8	8.0	5.7	0.0	1.1	0.0	12.8	5.7
	17	1.1	1.1	5.7	8.0	9.2	6.9	8.0	17.2	12.6	9.2	6.9	10.3	2.3	0.0	1.1	0.0	12.7	5.7
	18	1.1	1.1	4.6	6.9	6.9	9.2	10.3	12.6	21.8	4.6	9.2	8.0	1.1	1.1	1.1	0.0	13.0	5.8
	19	0.0	1.1	4.6	6.9	6.9	8.0	11.5	11.5	26.4	4.6	6.9	6.9	2.3	1.1	1.1	0.0	13.2	5.9
	20	0.0	1.1	4.6	8.0	9.2	11.5	6.9	11.5	18.4	4.6	12.6	6.9	2.3	1.1	1.1	0.0	13.3	6.0
	21	0.0	1.1	4.6	4.6	14.9	9.2	8.0	11.5	20.7	3.4	8.0	10.3	0.0	2.3	0.0	1.1	13.2	5.9
	22	0.0	1.2	7.0	5.8	12.8	9.3	11.6	7.0	18.6	7.0	9.3	5.8	3.5	0.0	1.2	0.0	12.8	5.7
	23	0.0	0.0	4.6	10.3	9.2	14.9	8.0	11.5	12.6	5.7	9.2	8.0	4.6	0.0	1.1	0.0	12.9	5.8
	24	0.0	0.0	6.9	9.2	10.3	14.9	9.2	6.9	19.5	1.1	9.2	5.7	4.6	1.1	1.1	0.0	12.5	5.6
ALL HOURS		0.9	1.8	6.5	7.9	9.9	10.4	9.9	11.8	17.2	3.6	7.7	6.9	3.8	1.1	0.6	0.0	12.4	5.6

SOURCE: GEORESEARCH, INC.

Table IV - 31

Percentage Frequency Summary for Wind Speed

DANIELS COUNTY - SCOBEY HANRAHAN (SPRING)

04/01/81 - 03/31/82

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)																
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	1.4	1.4	8.1	8.1	18.9	13.5	12.2	13.5	2.7	5.4	4.1	6.8	2.7	1.4	0.0	0.0	11.0	4.9
	2	1.4	1.4	6.8	11.0	17.8	9.6	11.0	13.7	11.0	4.1	4.1	5.5	1.4	1.4	0.0	0.0	10.9	4.9
	3	1.4	2.7	4.1	11.0	20.5	13.7	2.7	12.3	13.7	5.5	2.7	5.5	4.1	0.0	0.0	0.0	11.0	4.9
	4	2.7	0.0	6.7	9.3	12.0	22.7	9.3	8.0	9.3	6.7	2.7	5.3	4.0	1.3	0.0	0.0	11.1	5.0
	5	2.7	0.0	9.3	8.0	13.3	20.0	6.7	10.7	8.0	5.3	2.7	8.0	1.3	4.0	0.0	0.0	11.4	5.1
	6	2.7	0.0	8.1	13.5	16.2	14.9	10.8	4.1	6.8	4.1	8.1	5.4	2.7	2.7	0.0	0.0	11.1	5.0
	7	2.8	0.0	5.6	11.1	13.9	18.1	11.1	6.9	8.3	4.2	4.2	5.6	5.6	2.8	0.0	0.0	11.9	5.3
	8	2.8	0.0	2.8	11.1	15.3	8.3	15.3	8.3	8.3	4.2	8.3	5.6	2.8	5.6	1.4	0.0	13.2	5.9
H	9	2.8	1.4	1.4	9.7	15.3	5.6	9.7	11.1	8.3	6.9	9.7	5.6	6.9	1.4	4.2	0.0	13.9	6.2
	10	2.7	1.4	0.0	12.3	11.0	9.6	8.2	6.8	4.1	13.7	5.5	12.3	6.8	2.7	1.4	1.4	14.5	6.5
O	11	1.4	1.4	0.0	15.3	11.1	8.3	6.9	5.6	4.2	5.6	12.5	13.9	6.9	2.8	2.8	1.4	15.1	6.7
	12	0.0	1.4	1.4	10.8	8.1	9.5	8.1	9.5	8.1	6.8	5.4	18.9	6.8	1.4	2.7	1.4	15.5	6.9
U	13	0.0	0.0	6.8	5.4	5.4	14.9	6.8	6.8	6.8	4.1	16.2	16.2	6.8	2.7	1.4	0.0	15.5	6.9
	14	0.0	1.3	1.3	9.3	5.3	8.0	9.3	10.7	5.3	12.0	9.3	16.0	8.0	2.7	0.0	1.3	15.6	7.0
R	15	0.0	1.3	5.2	3.9	6.5	11.7	6.5	6.5	11.7	11.7	5.2	18.2	7.8	2.6	0.0	1.3	15.7	7.0
	16	1.3	0.0	3.8	6.4	7.7	6.4	12.8	11.5	7.7	6.4	3.8	20.5	9.0	1.3	0.0	1.3	15.3	6.9
	17	0.0	2.6	3.8	10.3	3.8	6.4	12.8	12.8	9.0	6.4	6.4	16.7	5.1	2.6	1.3	0.0	14.4	6.4
	18	0.0	1.3	9.0	3.8	6.4	11.5	14.1	7.7	14.1	6.4	5.1	12.8	6.4	1.3	0.0	0.0	13.7	6.1
	19	0.0	0.0	6.5	10.4	6.5	14.3	11.7	13.0	10.4	7.8	5.2	10.4	1.3	2.6	0.0	0.0	12.7	5.7
	20	0.0	3.9	6.5	10.4	16.9	7.8	11.7	13.0	9.1	0.0	6.5	11.7	0.0	2.6	0.0	0.0	11.6	5.2
	21	0.0	2.6	2.6	9.1	15.6	18.2	11.7	10.4	9.1	5.2	5.2	6.5	1.3	2.6	0.0	0.0	11.7	5.2
	22	0.0	2.6	1.3	11.8	11.8	14.5	17.1	7.9	11.8	5.3	7.9	3.9	1.3	2.6	0.0	0.0	12.0	5.4
	23	0.0	1.3	4.0	9.3	18.7	8.0	14.7	10.7	12.0	5.3	4.0	8.0	1.3	2.7	0.0	0.0	11.9	5.3
	24	0.0	1.3	5.3	11.8	9.2	19.7	10.5	11.8	9.2	3.9	3.9	2.6	6.6	2.6	0.0	1.3	12.6	5.6
ALL HOURS		1.1	1.2	4.6	9.7	11.9	12.3	10.5	9.7	8.7	6.1	6.2	10.1	4.5	2.3	0.6	0.4	13.1	5.8

SOURCE: GEORESEARCH, INC.

Table IV - 32

Percentage Frequency Summary for Wind Speed

DANIELS COUNTY - SCOBEY HANRAHAN (SUMMER)

04/01/81 - 03/31/82

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (M/SEC)															
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	0.0	6.2	16.0	19.8	13.6	13.6	13.6	12.3	2.5	1.2	1.2	0.0	0.0	0.0	0.0	9.4	4.2
	2	0.0	1.3	3.8	17.7	11.4	24.1	20.3	6.3	10.1	3.8	1.3	0.0	0.0	0.0	0.0	0.0	9.2	4.1
	3	0.0	0.0	5.0	21.3	18.8	11.3	25.0	10.0	3.8	3.8	0.0	1.3	0.0	0.0	0.0	0.0	8.8	3.9
	4	0.0	0.0	5.1	17.7	25.3	22.8	10.1	6.3	6.3	3.8	1.3	1.3	0.0	0.0	0.0	0.0	8.7	3.9
	5	0.0	1.3	7.7	23.1	14.1	19.2	16.7	7.7	3.8	3.8	1.3	1.3	0.0	0.0	0.0	0.0	8.5	3.8
	6	0.0	1.3	11.7	14.3	22.1	11.7	10.4	16.9	5.2	2.6	0.0	3.9	0.0	0.0	0.0	0.0	8.8	4.0
	7	0.0	1.3	5.3	15.8	19.7	13.2	15.8	11.8	7.9	5.3	1.3	2.6	0.0	0.0	0.0	0.0	9.5	4.3
	8	0.0	1.3	7.8	6.5	13.0	20.8	9.1	19.5	9.1	7.8	0.0	3.9	0.0	0.0	0.0	1.3	11.0	4.9
H	9	0.0	0.0	7.8	10.4	7.8	20.8	19.5	11.7	9.1	6.5	1.3	3.9	1.3	0.0	0.0	0.0	10.7	4.8
	10	0.0	0.0	6.3	8.9	11.4	16.5	16.5	13.9	10.1	7.6	2.5	3.8	1.3	1.3	0.0	0.0	11.4	5.1
O	11	0.0	0.0	5.1	7.6	7.6	17.7	12.7	17.7	12.7	5.1	3.8	8.9	1.3	0.0	0.0	0.0	12.0	5.4
	12	0.0	0.0	5.0	6.3	11.3	15.0	17.5	13.8	6.3	8.8	10.0	5.0	0.0	1.3	0.0	0.0	12.1	5.4
U	13	0.0	0.0	1.3	7.6	13.9	19.0	16.5	8.9	10.1	8.9	3.8	8.9	1.3	0.0	0.0	0.0	12.0	5.4
	14	0.0	0.0	2.6	7.7	15.4	17.9	10.3	12.8	14.1	11.5	3.8	3.8	0.0	0.0	0.0	0.0	11.5	5.2
R	15	0.0	0.0	3.8	3.8	18.8	18.8	8.8	13.8	6.3	13.8	5.0	5.0	1.3	1.3	0.0	0.0	12.0	5.4
	16	0.0	0.0	2.5	8.8	15.0	16.3	7.5	15.0	8.8	10.0	6.3	7.5	1.3	1.3	0.0	0.0	12.4	5.5
	17	0.0	1.3	5.1	6.3	12.7	17.7	7.6	11.4	10.1	16.5	3.8	5.1	0.0	0.0	2.5	0.0	12.3	5.5
	18	0.0	1.2	3.7	6.2	14.8	18.5	9.9	11.1	13.6	8.6	4.9	4.9	1.2	0.0	1.2	0.0	11.7	5.2
	19	0.0	1.3	3.8	17.7	8.9	15.2	13.9	15.2	12.7	2.5	5.1	1.3	1.3	0.0	1.3	0.0	10.8	4.8
	20	0.0	1.3	6.3	16.5	16.5	19.0	12.7	10.1	8.9	7.6	0.0	1.3	0.0	0.0	0.0	0.0	9.3	4.2
	21	0.0	1.3	7.6	20.3	15.2	17.7	16.5	3.8	7.6	5.1	2.5	1.3	1.3	0.0	0.0	0.0	9.2	4.1
	22	0.0	1.3	5.1	23.1	15.4	14.1	15.4	10.3	6.4	2.6	1.3	5.1	0.0	0.0	0.0	0.0	9.3	4.2
	23	0.0	1.3	12.8	20.5	12.8	17.9	9.0	11.5	7.7	1.3	2.6	1.3	1.3	0.0	0.0	0.0	8.7	3.9
	24	0.0	3.8	7.7	17.9	15.4	14.1	11.5	16.7	3.8	5.1	1.3	1.3	1.3	0.0	0.0	0.0	9.1	4.0
ALL HOURS		0.0	0.8	5.8	13.4	14.9	17.2	13.6	12.1	8.6	6.5	2.7	3.5	0.6	0.2	0.2	0.1	10.4	4.6

SOURCE: GEORESEARCH, INC.

Table IV - 33

Percentage Frequency Summary for Wind Speed

DANIELS COUNTY - SCOBEY HANRAHAN (AUTUMN)

04/01/81 - 03/31/82

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)																
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	7.1	1.2	2.4	15.5	8.3	16.7	11.9	9.5	10.7	7.1	4.8	1.2	3.6	0.0	0.0	0.0	10.2	4.5
	2	7.1	0.0	2.4	15.5	9.5	15.5	13.1	9.5	13.1	2.4	8.3	1.2	2.4	0.0	0.0	0.0	10.1	4.5
	3	7.1	1.2	2.4	17.9	13.1	13.1	13.1	7.1	10.7	4.8	3.6	3.6	2.4	0.0	0.0	0.0	9.8	4.4
	4	7.1	1.2	2.4	19.0	16.7	4.8	15.5	13.1	8.3	3.6	4.8	2.4	1.2	0.0	0.0	0.0	9.4	4.2
	5	8.3	1.2	3.6	15.5	16.7	6.0	17.9	9.5	7.1	4.8	6.0	3.6	0.0	0.0	0.0	0.0	9.3	4.2
	6	8.3	0.0	4.8	11.9	16.7	7.1	20.2	13.1	7.1	2.4	3.6	4.8	0.0	0.0	0.0	0.0	9.4	4.2
	7	7.1	0.0	8.3	10.7	17.9	11.9	16.7	9.5	8.3	4.8	1.2	3.6	0.0	0.0	0.0	0.0	8.9	4.0
	8	7.1	0.0	10.7	9.5	7.1	21.4	10.7	9.5	13.1	6.0	1.2	2.4	1.2	0.0	0.0	0.0	9.3	4.2
H	9	7.1	0.0	8.3	9.5	9.5	9.5	10.7	16.7	13.1	6.0	4.8	2.4	2.4	0.0	0.0	0.0	10.3	4.6
	10	7.1	2.4	7.1	7.1	6.0	11.9	10.7	14.3	10.7	6.0	4.8	9.5	1.2	1.2	0.0	0.0	11.2	5.0
O	11	7.1	1.2	10.7	4.8	11.9	2.4	7.1	15.5	15.5	4.8	3.6	10.7	2.4	2.4	0.0	0.0	11.8	5.3
	12	7.1	0.0	9.4	8.2	8.2	4.7	11.8	7.1	16.5	7.1	4.7	9.4	4.7	1.2	0.0	0.0	12.1	5.4
U	13	7.1	0.0	4.8	9.5	9.5	6.0	11.9	8.3	14.3	7.1	8.3	8.3	4.8	0.0	0.0	0.0	12.3	5.5
	14	7.1	0.0	6.0	6.0	9.5	6.0	10.7	10.7	13.1	9.5	7.1	8.3	4.8	1.2	0.0	0.0	12.6	5.6
R	15	7.1	1.2	4.7	5.9	7.1	11.8	7.1	10.6	11.8	11.8	5.9	8.2	4.7	2.4	0.0	0.0	12.9	5.8
	16	5.9	1.2	3.5	11.8	4.7	10.6	9.4	15.3	14.1	3.5	4.7	9.4	5.9	0.0	0.0	0.0	12.2	5.4
	17	5.9	1.2	5.9	5.9	9.4	16.5	15.3	8.2	9.4	9.4	3.5	4.7	4.7	0.0	0.0	0.0	11.1	5.0
	18	5.9	1.2	3.5	12.9	7.1	22.4	14.1	8.2	9.4	4.7	3.5	5.9	1.2	0.0	0.0	0.0	10.1	4.5
	19	5.9	1.2	4.7	15.3	17.6	14.1	9.4	5.9	12.9	4.7	5.9	0.0	2.4	0.0	0.0	0.0	9.5	4.3
	20	5.9	0.0	4.7	9.4	16.5	22.4	8.2	5.9	10.6	10.6	2.4	1.2	1.2	1.2	0.0	0.0	10.0	4.4
	21	5.9	0.0	2.4	11.8	16.5	14.1	8.2	18.8	7.1	7.1	3.5	1.2	2.4	1.2	0.0	0.0	10.3	4.6
	22	5.9	1.2	4.7	11.8	8.2	20.0	11.8	11.8	8.2	7.1	2.4	3.5	3.5	0.0	0.0	0.0	10.2	4.6
	23	5.9	2.4	2.4	10.6	8.2	22.4	10.6	12.9	9.4	2.4	4.7	4.7	3.5	0.0	0.0	0.0	10.4	4.7
	24	7.1	1.2	3.5	9.4	14.1	11.8	14.1	14.1	10.6	2.4	3.5	4.7	3.5	0.0	0.0	0.0	10.4	4.7
ALL HOURS		6.8	0.8	5.1	11.1	11.2	12.6	12.1	11.1	11.1	5.8	4.4	4.8	2.7	0.4	0.0	0.0	10.6	4.7

SOURCE: GEORESEARCH, INC.

Table IV - 34

Annual Wind Rose Distribution

DANIELS COUNTY - SCOBEY HANRAHAN

04/01/81 - 03/31/82

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1- 0.4
1.1- 2.0	0.2	0.2	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	2.5	0.5- 0.9
2.1- 3.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.1	2.0	1.0- 1.3
3.1- 4.0	0.2	0.1	0.1	0.1	0.3	0.4	0.2	0.3	0.1	0.5	0.6	0.4	0.6	0.4	0.5	0.4	5.3	1.4- 1.8
S 4.1- 5.0	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.0	0.1	0.3	0.3	0.2	0.4	0.2	0.2	0.1	2.6	1.9- 2.2
P 5.1- 6.0	0.3	0.2	0.3	0.1	0.4	0.4	0.3	0.3	0.3	0.4	0.8	0.8	0.5	0.5	0.5	0.3	6.6	2.3- 2.7
E 6.1- 7.0	0.2	0.3	0.1	0.3	0.5	0.6	0.4	0.3	0.5	0.7	0.8	0.8	0.8	0.6	0.5	0.2	7.6	2.8- 3.1
E 7.1- 8.0	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.3	0.1	0.2	0.2	0.2	0.2	0.1	0.0	2.2	3.2- 3.6
D 8.1- 9.0	0.3	0.4	0.5	0.4	0.9	0.7	0.6	0.5	1.0	0.5	0.8	1.4	0.9	0.8	0.8	0.3	10.6	3.7- 4.0
9.1-10.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.3	0.2	0.2	0.1	2.4	4.1- 4.5
M 10.1-11.0	0.2	0.3	0.4	0.3	0.8	0.5	0.5	0.5	0.7	0.3	0.6	1.0	0.8	0.6	0.6	0.3	8.4	4.6- 4.9
I 11.1-12.0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.1	0.2	0.3	0.3	0.3	0.2	0.1	3.1	5.0- 5.4
L 12.1-13.0	0.3	0.2	0.2	0.3	0.8	0.8	0.6	0.6	0.8	0.3	0.3	0.8	1.1	0.7	0.6	0.3	8.7	5.5- 5.8
E 13.1-14.0	0.1	0.0	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.0	0.1	0.3	0.3	0.2	0.1	0.1	2.5	5.9- 6.3
S 14.1-15.0	0.2	0.1	0.2	0.2	0.7	0.5	0.6	0.4	0.6	0.3	0.4	0.6	0.6	0.6	0.7	0.4	7.3	6.4- 6.7
/ 15.1-16.0	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.2	0.4	0.2	0.3	0.5	0.5	0.3	0.4	0.1	4.2	6.8- 7.2
H 16.1-17.0	0.1	0.1	0.0	0.1	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.1	2.8	7.3- 7.6
O 17.1-18.0	0.1	0.0	0.0	0.0	0.2	0.2	0.4	0.2	0.1	0.0	0.1	0.2	0.3	0.3	0.3	0.2	2.7	7.7- 8.0
U 18.1-19.0	0.0	0.1	0.0	0.0	0.1	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.4	0.5	0.2	2.9	8.1- 8.5
R 19.1-20.0	0.1	0.1	0.1	0.0	0.3	0.3	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.3	0.3	0.1	2.4	8.6- 8.9
20.1-25.0	0.1	0.1	0.1	0.1	0.7	0.8	0.5	0.5	0.3	0.1	0.0	0.3	0.5	0.8	0.9	0.3	6.3	9.0-11.2
25.1-30.0	0.1	0.0	0.0	0.0	0.3	0.2	0.2	0.3	0.1	0.0	0.0	0.1	0.2	0.5	0.6	0.2	2.9	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	1.0	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.4	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	>17.9
CALM																	2.3	CALM
TOTAL	3.2	2.6	2.6	2.6	7.7	7.8	6.9	5.9	6.5	4.4	6.4	9.1	9.3	8.9	9.3	4.4	100.0	TOTAL
AV SPD (MPH)	10.3	10.0	10.1	11.1	13.1	12.7	13.6	12.6	11.3	8.5	8.7	10.4	11.4	13.8	13.9	12.8	11.6	AV SPD (MPH)
AV SPD (M/S)	4.6	4.5	4.5	5.0	5.9	5.7	6.1	5.6	5.0	3.8	3.9	4.7	5.1	6.2	6.2	5.7	5.2	AV SPD (M/S)

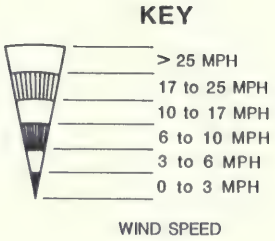
SOURCE: GEORESEARCH, INC.

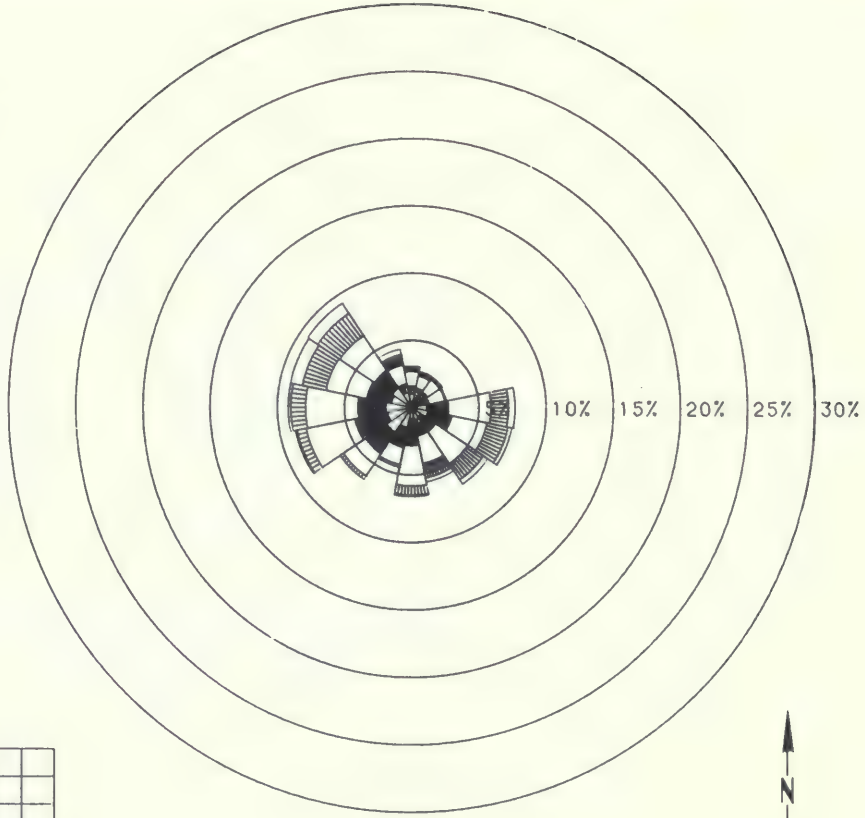
Figure IV - 3

Annual Wind Rose Distribution

SCOBEY HANRAHAN — DANIELS COUNTY

(1981 - 1982)





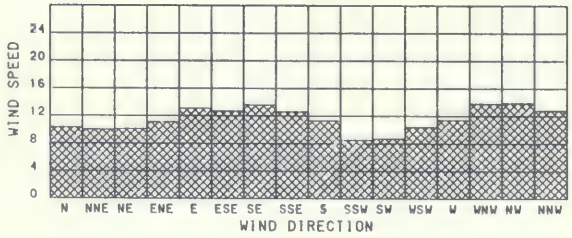


Table IV - 35

Coefficients of Weibull Distribution

DANIELS COUNTY - SCOBEY HANRAHAN

04/01/81 - 03/31/82

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.1983	2.3374
FEBRUARY	6.8582	2.5466
MARCH	7.4268	1.7912
APRIL	4.3728	1.9748
MAY	7.4408	2.3549
JUNE	5.6429	2.0810
JULY	4.7578	2.1759
AUGUST	4.4512	2.3026
SEPTEMBER	5.3096	1.8763
OCTOBER	6.7440	2.5343
NOVEMBER	4.4398	0.7107
DECEMBER	5.0115	1.5759
YEAR	5.8299	1.9077

SOURCE: GEORESEARCH, INC.

GLENDIVE MICROWAVE

DAWSON COUNTY

The Glendive Microwave site was located about 10 miles east of Glendive at 47 08 14 N and 104 32 45 W (Site No. 25 on Map II-1). Elevation at the site was 2,611 feet.

The area is rugged, badlands country, and access to the site is difficult, especially in the winter. Interstate Highway 94 runs to the south of the site. The land is mostly privately owned, although some sections of state-owned lands are scattered throughout the area.

A Montana-Dakota Utilities Company 57 kV transmission line runs within several miles of the site. The site itself was located at a microwave communications tower. The nearest commercial airport is at Glendive about 10 miles away.

Wind data were collected at the site by the Montana Air Quality Bureau from July 26, 1975, to September 14, 1977. The data set contains hourly averages for wind speed and wind direction manually reduced from strip-chart records. The data were collected by a Meteorology Research, Inc., mechanical wind speed and direction recording unit. Anemometer height was 4 meters.

Overall data recovery during the period was poor—only 35.6 percent. No data were collected during January. Winds were monitored long enough at this site to provide an indication of the wind resource at this location, but care must be used in interpreting this data. The site was located on an exposed, elevated ridge and is representative of similarly exposed areas around the site.

Average monthly wind speeds at this site ranged from 9.8 miles per hour in November to 14.2 miles per hour in March. Average annual wind speed was 12.2 miles per hour. March and April were the windiest months, while the calmest months were September and November.

Average annual wind power at the site was 168.5 watts/m². Average monthly wind power values ranged from 91.5 watts/m² in November to 272.0 watts/m² in March.

Average seasonal wind speeds were 11.0 miles per hour in autumn, 11.9 miles per hour in summer, 12.4 miles per hour in winter, and 13.7 miles per hour in spring. The highest average wind speeds occurred in late morning during spring and autumn, in mid-morning during the summer, and in early evening during the winter. The lowest average wind speeds occurred in early evening during the autumn, in late evening during spring and summer, and in the early morning during the winter. The diurnal range of average wind speeds was greatest in spring and least in summer.

Winds from the south-southwest and west-northwest were most common. Winds from the northeast and east were least common. By direction, average wind speeds ranged from 9.4 miles per hour for northeasterly winds to 15.6 miles per hour for southeasterly winds.

Table IV - 36

Monthly Wind Speed Distribution

DAWSON COUNTY - GLENDIVE MICROWAVE

07/26/75 - 09/14/77

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1- 0.4
1.1-2.0	0.0	0.0	0.0	0.5	0.8	0.1	0.3	0.8	0.1	0.2	0.4	0.0	0.3	0.5- 0.9
2.1-3.0	0.0	1.9	1.5	0.6	1.5	1.2	0.7	2.7	1.9	1.2	3.1	0.7	1.6	1.0- 1.3
3.1-4.0	0.0	4.3	1.5	1.6	3.4	2.6	2.0	4.0	5.1	5.3	5.9	2.6	3.6	1.4- 1.8
4.1-5.0	0.0	4.3	2.1	2.7	5.5	4.1	4.1	5.2	4.5	4.1	7.7	2.1	4.3	1.9- 2.2
5.1-6.0	0.0	4.3	4.8	3.3	3.1	3.5	5.8	6.1	5.8	3.2	6.4	4.0	4.7	2.3- 2.7
6.1-7.0	0.0	6.2	5.4	2.7	4.8	4.6	4.8	6.4	5.1	4.9	7.9	3.5	5.1	2.8- 3.1
7.1-8.0	0.0	3.8	5.7	5.0	4.4	5.1	5.6	6.6	5.3	3.9	7.5	2.6	5.2	3.2- 3.6
8.1-9.0	0.0	5.0	5.4	4.4	5.5	5.0	7.7	6.3	8.0	6.5	7.5	5.0	6.1	3.7- 4.0
9.1-10.0	0.0	4.8	5.4	5.2	4.8	5.6	9.0	6.8	8.6	6.1	6.6	4.9	6.3	4.1- 4.5
10.1-11.0	0.0	8.9	5.1	7.4	6.1	6.2	10.0	7.4	8.9	7.5	8.6	6.6	7.6	4.6- 4.9
11.1-12.0	0.0	7.4	5.4	6.7	5.7	5.1	7.3	5.7	7.5	7.0	5.5	7.3	6.4	5.0- 5.4
12.1-13.0	0.0	7.7	4.8	6.6	6.1	6.3	6.5	5.1	5.9	6.3	6.1	7.1	6.1	5.5- 5.8
13.1-14.0	0.0	7.0	3.9	6.3	8.2	7.2	6.5	6.3	4.9	7.0	4.8	9.4	6.5	5.9- 6.3
14.1-15.0	0.0	7.7	5.4	6.3	6.5	8.2	4.6	3.9	4.4	5.4	3.5	7.6	5.6	6.4- 6.7
15.1-16.0	0.0	5.3	4.8	5.2	5.9	6.9	3.4	3.5	6.4	6.6	2.2	5.6	5.1	6.8- 7.2
16.1-17.0	0.0	4.3	4.5	5.0	3.1	5.7	3.4	3.6	2.9	5.1	3.3	5.9	4.2	7.3- 7.6
17.1-18.0	0.0	4.3	3.9	4.5	4.0	4.0	2.7	3.0	2.6	4.3	5.0	5.7	3.9	7.7- 8.0
18.1-19.0	0.0	4.1	3.9	4.9	4.6	2.8	2.4	2.7	3.6	4.1	2.6	4.9	3.6	8.1- 8.5
19.1-20.0	0.0	2.6	3.0	2.8	1.3	2.3	1.2	2.7	1.8	2.7	2.2	4.9	2.5	8.6- 8.9
20.1-25.0	0.0	5.3	16.6	13.1	7.4	10.1	11.2	7.5	5.6	4.8	3.1	8.7	8.3	9,0-11.2
25.1-30.0	0.0	0.7	3.9	4.2	5.3	3.1	0.7	2.4	0.5	2.7	0.0	1.0	2.2	11.3-13.4
30.1-35.0	0.0	0.0	2.4	1.3	1.7	0.1	0.0	1.1	0.4	1.0	0.2	0.0	0.7	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	ND	11.6	14.2	14.0	12.9	12.8	11.7	11.5	10.9	12.1	9.8	13.0	12.2	
AVERAGE SPEED (M/SEC)	ND	5.2	6.3	6.3	5.8	5.7	5.2	5.1	4.9	5.4	4.4	5.8	5.4	
AVERAGE WIND POWER (WATTS/M**2)	ND	135.8	272.0	237.5	215.0	175.1	138.3	155.9	116.2	171.7	91.5	175.5	168.5	
PERCENT DATA RECOVERY	0.0	30.5	22.2	44.4	35.2	47.3	36.6	51.3	41.1	39.5	31.7	38.7	35.6	

SPEED / HOUR

WIND DIRECTION

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
NUMBER OF OBSERVATIONS = 6673
PERCENTAGE DATA RECOVERY = 35.6

SOURCE: GEORESEARCH, INC.

Table IV - 37

Percentage Frequency Summary for Wind Speed

DAWSON COUNTY - GLENDIVE MICROWAVE (WINTER)

07/26/75 - 09/14/77

		WIND SPEED (MPH)															
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
		WIND SPEED (M/SEC)															AV	AV
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	SPEED (MPH)	SPEED (M/SEC)
	1	0.0	0.0	0.0	7.3	9.8	9.8	22.0	19.5	9.8	12.2	7.3	2.4	0.0	0.0	0.0	0.0	11.9	5.3
	2	0.0	0.0	7.3	4.9	9.8	12.2	14.6	19.5	12.2	4.9	4.9	9.8	0.0	0.0	0.0	0.0	11.8	5.3
	3	0.0	0.0	9.8	7.3	4.9	12.2	22.0	12.2	12.2	2.4	9.8	7.3	0.0	0.0	0.0	0.0	11.6	5.2
	4	0.0	0.0	12.2	7.3	2.4	22.0	12.2	14.6	4.9	4.9	2.4	17.1	0.0	0.0	0.0	0.0	11.6	5.2
	5	0.0	0.0	9.8	9.8	12.2	4.9	17.1	14.6	12.2	0.0	7.3	12.2	0.0	0.0	0.0	0.0	11.5	5.1
	6	0.0	0.0	7.3	4.9	17.1	9.8	7.3	14.6	9.8	9.8	12.2	4.9	2.4	0.0	0.0	0.0	11.9	5.3
	7	0.0	0.0	9.8	2.4	14.6	7.3	14.6	9.8	14.6	9.8	12.2	4.9	0.0	0.0	0.0	0.0	11.8	5.3
	8	0.0	0.0	4.9	9.8	14.6	2.4	14.6	24.4	17.1	4.9	4.9	0.0	2.4	0.0	0.0	0.0	11.2	5.0
H	9	0.0	0.0	2.4	19.5	0.0	14.6	12.2	14.6	19.5	9.8	2.4	2.4	2.4	0.0	0.0	0.0	11.4	5.1
	10	0.0	0.0	4.9	12.2	7.3	0.0	17.1	14.6	17.1	7.3	9.8	4.9	4.9	0.0	0.0	0.0	12.7	5.7
O	11	0.0	0.0	4.9	9.8	4.9	4.9	12.2	19.5	12.2	7.3	19.5	2.4	2.4	0.0	0.0	0.0	12.9	5.8
	12	0.0	0.0	4.9	12.2	7.3	2.4	9.8	14.6	22.0	7.3	9.8	9.8	0.0	0.0	0.0	0.0	12.8	5.7
U	13	0.0	0.0	12.2	2.4	4.9	9.8	17.1	9.8	17.1	4.9	12.2	9.8	0.0	0.0	0.0	0.0	12.6	5.6
	14	0.0	0.0	4.9	12.2	4.9	7.3	17.1	19.5	12.2	7.3	7.3	4.9	2.4	0.0	0.0	0.0	12.2	5.5
R	15	0.0	0.0	2.4	12.2	2.4	12.2	9.8	14.6	19.5	14.6	4.9	7.3	0.0	0.0	0.0	0.0	12.5	5.6
	16	0.0	0.0	2.4	9.5	4.8	14.3	7.1	11.9	11.9	16.7	9.5	11.9	0.0	0.0	0.0	0.0	13.1	5.9
	17	0.0	0.0	2.4	11.9	2.4	14.3	9.5	11.9	7.1	19.0	11.9	9.5	0.0	0.0	0.0	0.0	13.2	5.9
	18	0.0	0.0	0.0	4.8	7.1	11.9	19.0	16.7	2.4	9.5	19.0	7.1	2.4	0.0	0.0	0.0	13.5	6.0
	19	0.0	0.0	2.4	0.0	4.8	9.5	14.3	16.7	9.5	21.4	7.1	11.9	2.4	0.0	0.0	0.0	14.1	6.3
	20	0.0	0.0	2.4	0.0	9.5	9.5	14.3	11.9	14.3	16.7	7.1	14.3	0.0	0.0	0.0	0.0	13.7	6.1
	21	0.0	0.0	2.4	4.8	4.8	9.5	9.5	16.7	21.4	14.3	11.9	4.8	0.0	0.0	0.0	0.0	13.2	5.9
	22	0.0	0.0	0.0	4.8	7.1	11.9	19.0	21.4	9.5	19.0	2.4	4.8	0.0	0.0	0.0	0.0	12.5	5.6
	23	0.0	0.0	0.0	2.4	14.3	7.1	28.6	14.3	14.3	9.5	4.8	4.8	0.0	0.0	0.0	0.0	12.2	5.4
	24	0.0	0.0	0.0	0.0	14.3	16.7	16.7	19.0	11.9	14.3	2.4	4.8	0.0	0.0	0.0	0.0	12.1	5.4
ALL HOURS		0.0	0.0	4.5	7.2	7.8	9.9	14.9	15.7	13.1	10.4	8.5	7.3	0.9	0.0	0.0	0.0	12.4	5.6

SOURCE: GEORESEARCH, INC.

Table IV - 38

Percentage Frequency Summary for Wind Speed

DAWSON COUNTY - GLENDIVE MICROWAVE (SPRING)

07/26/75 - 09/14/77

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (M/SEC)															
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	0.0	8.1	6.5	16.1	6.5	11.3	8.1	16.1	9.7	1.6	12.9	3.2	0.0	0.0	0.0	12.3	5.5
	2	0.0	1.6	4.8	8.1	12.9	11.3	9.7	16.1	6.5	11.3	3.2	11.3	1.6	1.6	0.0	0.0	12.4	5.5
	3	0.0	1.6	8.1	8.1	8.1	12.9	12.9	9.7	8.1	14.5	4.8	6.5	3.2	1.6	0.0	0.0	12.3	5.5
	4	0.0	1.6	6.5	6.5	14.5	8.1	12.9	8.1	14.5	12.9	1.6	8.1	0.0	4.8	0.0	0.0	12.4	5.6
	5	0.0	0.0	8.2	9.8	8.2	8.2	9.8	9.8	11.5	13.1	6.6	9.8	1.6	3.3	0.0	0.0	12.9	5.8
	6	0.0	1.6	6.6	4.9	9.8	11.5	9.8	8.2	16.4	4.9	4.9	14.8	4.9	1.6	0.0	0.0	13.5	6.0
	7	0.0	0.0	3.2	11.3	6.5	3.2	22.6	8.1	9.7	6.5	3.2	19.4	4.8	1.6	0.0	0.0	14.0	6.3
	8	0.0	0.0	3.2	6.5	11.3	3.2	16.1	16.1	6.5	6.5	12.9	9.7	6.5	1.6	0.0	0.0	14.0	6.2
H	9	0.0	0.0	0.0	8.1	9.7	6.5	6.5	19.4	16.1	8.1	6.5	9.7	9.7	0.0	0.0	0.0	14.5	6.5
	10	0.0	0.0	0.0	3.2	6.5	9.7	17.7	6.5	17.7	9.7	6.5	11.3	8.1	3.2	0.0	0.0	15.2	6.8
O	11	0.0	0.0	0.0	3.2	3.2	9.7	17.7	11.3	12.9	9.7	8.1	8.1	12.9	3.2	0.0	0.0	15.9	7.1
	12	0.0	1.6	0.0	3.2	4.8	11.3	9.7	14.5	12.9	6.5	9.7	12.9	8.1	3.2	1.6	0.0	15.9	7.1
U	13	0.0	1.6	0.0	6.6	3.3	11.5	9.8	14.8	13.1	9.8	4.9	8.2	9.8	6.6	0.0	0.0	15.6	7.0
	14	0.0	0.0	0.0	4.9	11.5	3.3	6.6	18.0	11.5	3.3	16.4	14.8	6.6	3.3	0.0	0.0	15.8	7.1
R	15	0.0	0.0	1.6	4.9	6.6	9.8	8.2	6.6	19.7	6.6	13.1	13.1	6.6	3.3	0.0	0.0	15.6	7.0
	16	0.0	0.0	4.9	1.6	9.8	9.8	11.5	11.5	13.1	9.8	13.1	9.8	3.3	1.6	0.0	0.0	14.1	6.3
	17	0.0	0.0	0.0	6.3	15.9	11.1	12.7	12.7	9.5	3.2	9.5	14.3	4.8	0.0	0.0	0.0	13.6	6.1
	18	0.0	0.0	0.0	6.3	10.9	14.1	9.4	14.1	10.9	6.3	7.8	17.2	3.1	0.0	0.0	0.0	13.7	6.1
	19	0.0	0.0	3.1	7.8	6.3	14.1	12.5	15.6	9.4	4.7	10.9	14.1	1.6	0.0	0.0	0.0	13.2	5.9
	20	0.0	0.0	6.3	7.8	4.7	14.1	14.1	14.1	6.3	17.2	0.0	12.5	3.1	0.0	0.0	0.0	12.7	5.7
	21	0.0	0.0	6.3	10.9	6.3	15.6	15.6	10.9	9.4	7.8	4.7	10.9	1.6	0.0	0.0	0.0	12.0	5.4
	22	0.0	1.6	0.0	11.1	14.3	7.9	19.0	14.3	3.2	12.7	1.6	12.7	1.6	0.0	0.0	0.0	12.1	5.4
	23	0.0	0.0	3.2	11.1	7.9	14.3	12.7	15.9	9.5	6.3	6.3	9.5	3.2	0.0	0.0	0.0	12.4	5.5
	24	0.0	0.0	6.3	11.1	6.3	14.3	11.1	14.3	12.7	1.6	7.9	14.3	0.0	0.0	0.0	0.0	12.2	5.4
ALL HOURS		0.0	0.5	3.3	7.1	9.0	10.1	12.5	12.4	11.5	8.4	6.9	11.9	4.6	1.7	0.1	0.0	13.7	6.1

SOURCE: GEORESEARCH, INC.

Table IV - 39

Percentage Frequency Summary for Wind Speed

DAWSON COUNTY - GLENDIVE MICROWAVE (SUMMER)

07/26/75 - 09/14/77

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)																
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	0.0	4.0	17.0	9.0	15.0	10.0	13.0	11.0	5.0	7.0	8.0	1.0	0.0	0.0	0.0	11.3	5.1
	2	0.0	1.0	6.0	10.0	13.0	16.0	10.0	12.0	8.0	8.0	4.0	11.0	0.0	1.0	0.0	0.0	11.5	5.1
	3	0.0	2.0	7.0	11.0	8.0	7.0	18.0	18.0	9.0	7.0	5.0	8.0	0.0	0.0	0.0	0.0	11.4	5.1
	4	0.0	1.0	10.0	5.0	12.0	12.0	15.0	14.0	9.0	8.0	9.0	4.0	1.0	0.0	0.0	0.0	11.2	5.0
	5	0.0	3.0	6.1	6.1	14.1	7.1	18.2	14.1	9.1	14.1	2.0	5.1	1.0	0.0	0.0	0.0	11.2	5.0
	6	0.0	1.0	10.1	9.1	9.1	12.1	13.1	13.1	13.1	6.1	5.1	7.1	0.0	1.0	0.0	0.0	11.2	5.0
	7	0.0	1.0	9.1	14.1	11.1	5.1	13.1	9.1	12.1	9.1	6.1	8.1	1.0	1.0	0.0	0.0	11.6	5.2
	8	0.0	0.0	4.0	14.1	7.1	16.2	10.1	11.1	13.1	8.1	5.1	8.1	2.0	1.0	0.0	0.0	12.0	5.4
H	9	0.0	0.0	2.0	7.1	13.1	11.1	12.1	14.1	4.0	13.1	5.1	13.1	4.0	1.0	0.0	0.0	13.3	5.9
	10	0.0	0.0	3.0	5.9	6.9	17.8	15.8	13.9	7.9	4.0	5.9	13.9	4.0	1.0	0.0	0.0	13.1	5.9
O	11	0.0	0.0	1.0	12.9	13.9	9.9	14.9	14.9	7.9	5.9	5.0	8.9	3.0	2.0	0.0	0.0	12.4	5.5
	12	0.0	0.0	1.0	9.9	10.9	15.8	20.8	7.9	6.9	4.0	8.9	9.9	2.0	2.0	0.0	0.0	12.6	5.6
U	13	0.0	0.0	1.0	15.8	8.9	17.8	11.9	9.9	5.9	5.9	3.0	14.9	4.0	1.0	0.0	0.0	12.5	5.6
	14	0.0	0.0	3.9	13.7	8.8	14.7	12.7	6.9	9.8	7.8	2.9	13.7	3.9	1.0	0.0	0.0	12.4	5.5
R	15	0.0	0.0	2.9	10.8	14.7	8.8	10.8	14.7	8.8	6.9	2.9	13.7	4.9	0.0	0.0	0.0	12.7	5.7
	16	0.0	0.0	2.9	7.8	21.6	7.8	11.8	6.9	15.7	6.9	2.9	12.7	2.0	1.0	0.0	0.0	12.4	5.6
	17	0.0	0.0	5.9	11.8	11.8	7.8	13.7	8.8	12.7	7.8	4.9	9.8	3.9	1.0	0.0	0.0	12.4	5.5
	18	0.0	0.0	2.9	11.8	10.8	13.7	9.8	10.8	9.8	12.7	3.9	8.8	3.9	0.0	1.0	0.0	12.7	5.7
	19	0.0	0.0	4.0	4.0	11.9	11.9	20.8	9.9	12.9	6.9	5.9	9.9	2.0	0.0	0.0	0.0	12.5	5.6
	20	0.0	0.0	4.0	4.0	14.9	18.8	13.9	19.8	5.0	7.9	5.0	5.0	2.0	0.0	0.0	0.0	11.4	5.1
	21	0.0	0.0	6.9	13.7	8.8	16.7	13.7	11.8	5.9	6.9	5.9	8.8	1.0	0.0	0.0	0.0	11.1	5.0
	22	0.0	1.0	7.0	10.0	12.0	18.0	14.0	10.0	9.0	6.0	3.0	9.0	1.0	0.0	0.0	0.0	10.9	4.9
	23	0.0	1.0	8.0	5.0	9.0	21.0	10.0	15.0	16.0	5.0	4.0	4.0	2.0	0.0	0.0	0.0	11.2	5.0
	24	0.0	1.0	6.0	8.0	13.0	16.0	13.0	17.0	11.0	3.0	5.0	4.0	3.0	0.0	0.0	0.0	11.2	5.0
ALL HOURS		0.0	0.5	4.9	9.9	11.4	13.3	13.6	12.3	9.7	7.3	4.9	9.2	2.2	0.6	0.0	0.0	11.9	5.3

SOURCE: GEORESEARCH, INC.

Table IV - 40

Percentage Frequency Summary for Wind Speed

DAWSON COUNTY - GLENDIVE MICROWAVE (AUTUMN)

07/26/75 - 09/14/77

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (M/SEC)															
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	0.0	8.0	12.0	10.7	13.3	8.0	14.7	13.3	6.7	5.3	5.3	2.7	0.0	0.0	0.0	11.3	5.0
	2	0.0	0.0	2.7	16.2	9.5	13.5	9.5	14.9	9.5	10.8	8.1	4.1	1.4	0.0	0.0	0.0	11.5	5.1
	3	0.0	0.0	2.7	8.1	18.9	12.2	13.5	6.8	13.5	12.2	5.4	5.4	1.4	0.0	0.0	0.0	11.5	5.1
	4	0.0	0.0	4.1	8.1	14.9	14.9	16.2	5.4	16.2	9.5	6.8	1.4	1.4	1.4	0.0	0.0	11.4	5.1
	5	0.0	1.4	4.1	6.8	16.2	14.9	16.2	16.2	8.1	8.1	2.7	2.7	2.7	0.0	0.0	0.0	11.0	4.9
	6	0.0	0.0	5.4	8.1	10.8	17.6	16.2	13.5	6.8	8.1	8.1	2.7	2.7	0.0	0.0	0.0	11.3	5.0
	7	0.0	0.0	5.4	8.1	9.5	9.5	20.3	16.2	9.5	6.8	8.1	4.1	2.7	0.0	0.0	0.0	11.7	5.2
	8	0.0	0.0	1.4	9.5	13.5	13.5	16.2	14.9	9.5	8.1	8.1	5.4	0.0	0.0	0.0	0.0	11.4	5.1
H	9	0.0	0.0	4.1	8.2	11.0	13.7	16.4	13.7	8.2	11.0	8.2	4.1	1.4	0.0	0.0	0.0	11.7	5.2
	10	0.0	1.4	2.7	6.8	11.0	13.7	15.1	12.3	12.3	9.6	5.5	6.8	2.7	0.0	0.0	0.0	12.1	5.4
O	11	0.0	0.0	2.8	6.9	8.3	13.9	19.4	11.1	8.3	13.9	6.9	5.6	2.8	0.0	0.0	0.0	12.4	5.6
	12	0.0	0.0	5.6	4.2	8.3	16.7	15.3	6.9	15.3	11.1	9.7	5.6	0.0	1.4	0.0	0.0	12.4	5.5
U	13	0.0	0.0	2.7	8.2	11.0	19.2	13.7	8.2	15.1	9.6	5.5	5.5	0.0	1.4	0.0	0.0	11.8	5.3
	14	0.0	0.0	5.5	11.0	11.0	17.8	17.8	8.2	11.0	8.2	1.4	6.8	0.0	1.4	0.0	0.0	10.9	4.9
R	15	0.0	1.4	12.3	11.0	8.2	17.8	12.3	9.6	9.6	4.1	4.1	8.2	0.0	0.0	1.4	0.0	10.6	4.7
	16	0.0	0.0	6.8	17.8	9.6	15.1	12.3	12.3	8.2	5.5	4.1	6.8	0.0	1.4	0.0	0.0	10.4	4.7
	17	0.0	0.0	9.6	9.6	13.7	15.1	17.8	9.6	5.5	4.1	9.6	4.1	0.0	1.4	0.0	0.0	10.7	4.8
	18	0.0	0.0	5.3	10.7	24.0	18.7	14.7	6.7	8.0	1.3	5.3	4.0	1.3	0.0	0.0	0.0	9.8	4.4
	19	0.0	0.0	14.7	10.7	13.3	17.3	17.3	9.3	8.0	2.7	1.3	5.3	0.0	0.0	0.0	0.0	9.4	4.2
	20	0.0	0.0	14.7	17.3	6.7	10.7	20.0	12.0	6.7	4.0	5.3	2.7	0.0	0.0	0.0	0.0	9.4	4.2
	21	0.0	0.0	12.0	14.7	8.0	16.0	16.0	9.3	9.3	5.3	2.7	6.7	0.0	0.0	0.0	0.0	10.0	4.5
	22	0.0	0.0	14.7	14.7	5.3	16.0	8.0	16.0	8.0	6.7	5.3	2.7	1.3	1.3	0.0	0.0	10.3	4.6
	23	0.0	1.3	12.0	9.3	6.7	8.0	21.3	14.7	9.3	6.7	2.7	4.0	1.3	2.7	0.0	0.0	11.1	5.0
	24	0.0	0.0	16.0	8.0	8.0	12.0	10.7	17.3	9.3	6.7	6.7	2.7	1.3	1.3	0.0	0.0	10.7	4.8
ALL HOURS		0.0	0.2	7.3	10.3	11.2	14.6	15.2	11.7	9.9	7.5	5.7	4.7	1.1	0.6	0.1	0.0	11.0	4.9

SOURCE: GEORESEARCH, INC.

Table IV - 41

Annual Wind Rose Distribution

DAWSON COUNTY - GLENDIVE MICROWAVE

07/26/75 - 09/14/77

DIRECTION> / SPEED (MPH)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION / SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1- 0.4
1.1- 2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.0	0.1	1.1	0.5- 0.9
2.1- 3.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.5	0.1	0.3	0.3	0.3	0.1	0.1	2.5	1.0- 1.3
3.1- 4.0	0.2	0.1	0.1	0.2	0.1	0.3	0.1	0.3	0.5	0.6	0.2	0.5	0.3	0.6	0.1	0.1	4.4	1.4- 1.8
S 4.1- 5.0	0.2	0.3	0.1	0.3	0.1	0.1	0.0	0.4	0.4	0.8	0.1	0.7	0.3	0.3	0.1	0.1	4.5	1.9- 2.2
P 5.1- 6.0	0.3	0.3	0.1	0.4	0.2	0.2	0.0	0.4	0.3	0.6	0.2	0.5	0.4	0.5	0.1	0.5	5.2	2.3- 2.7
E 6.1- 7.0	0.2	0.3	0.2	0.6	0.1	0.3	0.1	0.5	0.4	0.5	0.2	0.5	0.3	0.4	0.1	0.3	5.0	2.8- 3.1
E 7.1- 8.0	0.3	0.4	0.3	0.4	0.1	0.3	0.2	0.7	0.4	0.6	0.2	0.6	0.3	0.6	0.2	0.4	5.9	3.2- 3.6
D 8.1- 9.0	0.3	0.3	0.4	0.6	0.2	0.3	0.2	0.5	0.6	0.6	0.3	0.6	0.4	0.4	0.2	0.4	6.3	3.7- 4.0
9.1-10.0	0.3	0.3	0.3	0.6	0.3	0.6	0.2	0.5	0.7	0.9	0.3	0.6	0.4	0.6	0.2	0.4	7.3	4.1- 4.5
M 10.1-11.0	0.1	0.4	0.2	0.2	0.2	0.7	0.6	0.6	0.5	1.0	0.3	0.6	0.3	0.6	0.2	0.4	6.8	4.6- 4.9
I 11.1-12.0	0.2	0.3	0.1	0.2	0.1	0.8	0.4	0.5	0.6	1.0	0.4	0.7	0.3	0.5	0.2	0.3	6.5	5.0- 5.4
L 12.1-13.0	0.1	0.4	0.1	0.2	0.1	0.9	0.6	0.6	0.8	1.0	0.3	0.4	0.2	0.5	0.2	0.2	6.7	5.5- 5.8
E 13.1-14.0	0.3	0.1	0.2	0.2	0.1	0.7	0.4	0.4	0.6	1.1	0.2	0.4	0.2	0.6	0.2	0.2	5.9	5.9- 6.3
S 14.1-15.0	0.3	0.2	0.1	0.3	0.2	0.7	0.4	0.3	0.4	0.7	0.2	0.3	0.3	0.5	0.1	0.3	5.3	6.4- 6.7
/ 15.1-16.0	0.1	0.1	0.0	0.2	0.2	0.5	0.4	0.4	0.3	0.6	0.2	0.3	0.2	0.6	0.2	0.3	4.5	6.8- 7.2
H 16.1-17.0	0.3	0.3	0.0	0.1	0.1	0.5	0.2	0.4	0.3	0.4	0.2	0.2	0.2	0.6	0.1	0.1	4.0	7.3- 7.6
O 17.1-18.0	0.1	0.2	0.0	0.1	0.1	0.3	0.3	0.3	0.2	0.5	0.2	0.2	0.2	0.4	0.3	0.1	3.6	7.7- 8.0
U 18.1-19.0	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.2	0.2	0.4	0.1	0.3	0.1	0.4	0.2	0.1	2.8	8.1- 8.5
R 19.1-20.0	0.1	0.1	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.3	0.0	0.2	0.1	0.4	0.1	0.1	2.0	8.6- 8.9
20.1-25.0	0.5	0.3	0.0	0.1	0.1	0.8	0.8	0.8	0.1	0.3	0.1	0.4	0.6	1.1	0.4	0.3	6.7	9.0-11.2
25.1-30.0	0.2	0.0	0.0	0.0	0.0	0.1	0.4	0.4	0.0	0.0	0.0	0.1	0.2	0.3	0.1	0.2	2.2	11.3-13.4
30.1-35.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.7	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
CALM																	0.0	CALM
TOTAL	4.3	4.7	2.4	5.1	2.5	8.6	5.9	8.7	7.6	12.6	3.9	8.6	5.7	10.5	3.5	5.3	100.0	TOTAL
AV SPD (MPH)	13.7	11.4	9.4	9.9	11.6	13.8	15.6	12.6	10.8	11.2	11.1	10.6	12.1	13.2	14.1	12.2	12.2	AV SPD (MPH)
AV SPD (M/S)	6.1	5.1	4.2	4.4	5.2	6.2	7.0	5.7	4.8	5.0	4.9	4.8	5.4	5.9	6.3	5.4	5.4	AV SPD (M/S)

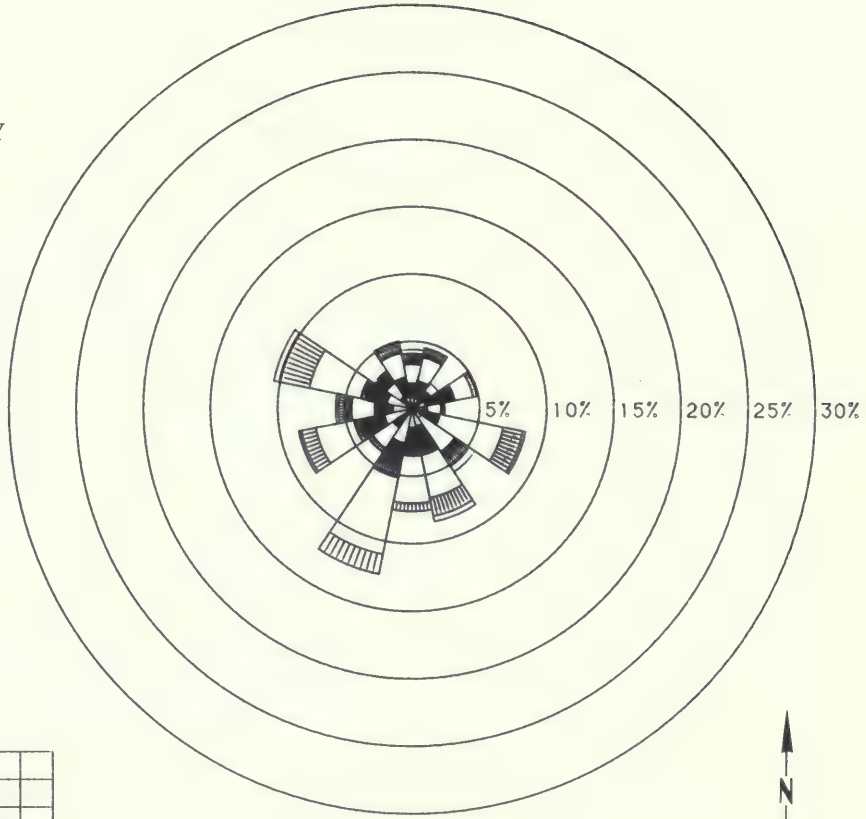
SOURCE: GEORESEARCH, INC.

Figure IV - 4

Annual Wind Rose Distribution

GLENDIVE MICROWAVE — DAWSON COUNTY

(1975 - 1977)



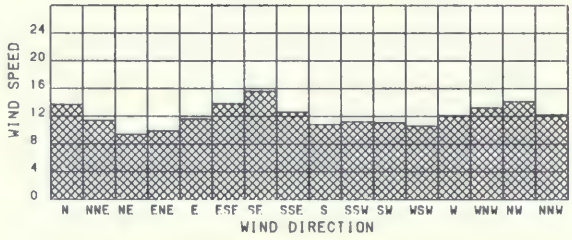


Table IV - 42

Coefficients of Weibull Distribution

DAWSON COUNTY - GLENDIVE MICROWAVE

07/26/75 - 09/14/77

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	ND	ND
FEBRUARY	6.2243	2.4371
MARCH	7.1117	2.0366
APRIL	6.9616	2.4669
MAY	6.5302	2.1645
JUNE	6.6135	2.4287
JULY	5.5014	2.5443
AUGUST	5.6390	1.9999
SEPTEMBER	5.5526	2.2842
OCTOBER	6.3426	2.3552
NOVEMBER	5.0772	2.0432
DECEMBER	5.4250	2.4484
YEAR	5.4542	2.0683

SOURCE: GEORESEARCH, INC.

ANACONDA C-HILL

DEER LODGE COUNTY

The C-Hill air monitoring site was located approximately 1 mile south of Anaconda at 46 06 03 N and 112 56 56 W (Site No. 27 on Map II-1). Elevation at the site was 7,193 feet. The site was established by the Anaconda Copper Company to measure concentrations of sulfur dioxide.

The land around the site is very rugged. To the southwest the Anaconda Range rises to more than 11,000 feet. To the north is the Flint Creek Range, with summits over 10,000 feet. The area is dissected by many deep canyons.

The Anaconda Copper Company owns the land around the site, so access is restricted. In general, land in the valleys is privately owned, and land in the mountains is controlled by the U.S. Forest Service. Several major electrical transmission lines run through the Deer Lodge valley. The nearest commercial airport is the Anaconda airport, about 5 miles northeast of the site.

Wind data from January 1, 1976, through May 31, 1979, were available for analysis. The data set consists of hourly averages of wind speed and wind direction manually reduced from stripchart records. Anemometer height was 10 meters.

Data recovery ranged from 39.4 percent in March to 91.7 percent in December. Overall data recovery was 59.6 percent.

Wind monitoring was conducted long enough to adequately represent the wind resource at this location. Because of the region's complex terrain, however, the data are representative only of a small area in the immediate vicinity of the site, which is on the crest of a high ridge. The rugged nature of the site limits the possibilities for development.

Average annual wind speed at this site was 13.3 miles per hour. Average monthly wind speeds ranged from 9.8 miles per hour in July to 17.5 miles per hour in December.

Average monthly wind power varied from 106.6 watts/m^2 in July to 618.3 watts/m^2 in December. Average annual wind power was 279.8 watts/m^2.

Average seasonal wind speeds were 11.2 miles per hour in summer, 11.4 miles per hour in autumn, 14.2 miles per hour in spring, and 15.4 miles per hour in winter. During all seasons the average wind speed was highest during the afternoon hours. In spring and summer, the highest average wind speeds occurred later in the afternoon (1700 and 1600 MST, respectively) than in the other two seasons. Average wind speeds were lowest from about 0700 to 0800 MST during all seasons except autumn, when the lowest average speeds occurred at 0400 MST.

The diurnal range of average hourly speeds was greatest in summer and least in winter. Most of the differences in average wind speeds among the seasons were due to variations in the average nighttime wind speed.

The annual wind rose distribution shows that winds were most common from the west to south-southwest. Winds from the north-northwest through north-northeast were least common. The highest average wind speeds, 14 to 19 miles per hour, were recorded for winds from the south-southwest through west. The lowest average speeds, less than 6 miles per hour, were recorded for winds from the north through north-northeast.

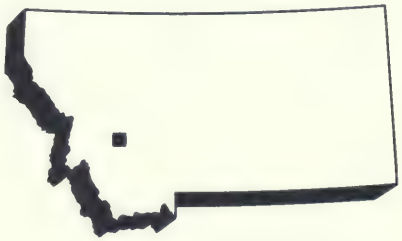


Table IV - 43

Monthly Wind Speed Distribution

DEER LODGE COUNTY - ANACONDA C-HILL

01/01/76 - 05/31/79

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM	0.1	0.1	0.3	1.2	0.2	0.1	0.5	0.1	0.5	0.6	0.3	0.1	0.4	CALM	
0.1-1.0	1.5	1.0	0.4	0.3	0.6	0.3	0.7	0.2	0.6	1.0	0.5	0.5	0.7	0.1- 0.4	
1.1-2.0	3.5	2.1	1.4	2.1	1.1	1.5	3.2	2.2	3.2	2.9	2.8	1.2	2.2	0.5- 0.9	S
S 2.1-3.0	3.4	2.9	2.8	3.2	2.1	3.0	5.5	3.3	5.1	5.0	4.7	1.9	3.5	1.0- 1.3	P
P 3.1-4.0	4.8	3.4	2.8	3.5	3.5	2.8	6.0	5.0	4.6	5.8	5.5	3.2	4.2	1.4- 1.8	E
E 4.1-5.0	4.5	3.5	3.3	4.8	3.2	5.9	7.9	5.2	5.2	6.4	6.3	3.5	4.8	1.9- 2.2	E
E 5.1-6.0	5.0	4.1	3.6	4.5	4.8	5.6	7.7	7.2	6.0	6.0	6.1	3.2	5.1	2.3- 2.7	D
D 6.1-7.0	5.7	3.8	3.9	4.6	4.5	6.1	7.8	7.5	5.9	7.0	6.7	3.4	5.4	2.8- 3.1	
7.1-8.0	5.2	3.6	4.4	5.1	4.7	6.1	6.4	7.2	5.7	6.0	4.5	3.8	5.1	3.2- 3.6	M
M 8.1-9.0	5.2	2.9	4.6	5.5	5.5	5.6	6.8	7.4	6.2	4.7	4.8	3.9	5.2	3.7- 4.0	E
I 9.1-10.0	5.1	3.6	4.3	3.9	4.9	6.0	6.2	6.3	5.7	4.9	5.0	3.8	4.9	4.1- 4.5	T
L 10.1-11.0	5.4	3.7	4.4	3.9	5.2	5.6	5.3	5.7	5.8	4.4	5.9	4.5	4.9	4.6- 4.9	E
E 11.1-12.0	5.0	3.9	5.0	4.8	5.5	4.4	5.1	5.9	5.2	4.4	4.5	4.5	4.9	5.0- 5.4	R
S 12.1-13.0	4.8	3.7	4.0	4.0	5.8	4.8	3.9	5.3	4.6	3.5	3.9	3.4	4.3	5.5- 5.8	S
/ 13.1-14.0	5.1	3.4	3.6	3.6	4.7	3.8	4.5	4.1	4.2	4.1	6.1	4.3	4.3	5.9- 6.3	/
H 14.1-15.0	4.4	3.6	3.3	3.4	4.5	3.6	3.2	3.1	4.0	4.3	3.4	4.3	3.9	6.4- 6.7	S
O 15.1-16.0	3.6	3.0	4.3	2.8	3.8	3.2	2.9	2.7	3.3	3.8	3.2	3.7	3.4	6.8- 7.2	E
U 16.1-17.0	3.1	3.5	4.1	3.8	3.9	3.0	2.4	3.1	4.0	3.2	2.7	3.2	3.4	7.3- 7.6	C
R 17.1-18.0	2.6	2.9	4.7	3.1	3.6	3.1	1.4	3.7	2.7	3.3	2.5	2.7	3.0	7.7- 8.0	O
18.1-19.0	2.8	3.4	3.1	3.9	3.8	3.0	1.3	2.0	2.1	2.1	3.0	3.7	2.9	8.1- 8.5	N
19.1-20.0	2.3	2.5	4.2	3.2	3.1	2.5	1.5	2.3	3.0	2.0	2.0	2.7	2.6	8.6- 8.9	D
20.1-25.0	8.6	14.5	12.8	12.9	13.3	10.9	7.0	6.6	9.2	9.4	8.6	12.3	10.7	9,0-11.2	
25.1-30.0	4.1	10.5	6.7	6.7	5.6	5.9	1.6	2.5	2.2	3.0	3.2	7.7	5.1	11.3-13.4	
30.1-35.0	1.6	5.7	3.3	3.3	1.4	2.0	0.6	0.9	0.8	1.4	1.7	6.2	2.5	13.5-15.6	
35.1-40.0	0.9	2.0	1.9	1.4	0.5	0.9	0.2	0.4	0.2	0.7	0.9	3.2	1.2	15.7-17.9	
>40.0	1.6	2.7	2.7	0.7	0.1	0.4	0.2	0.1	0.2	0.2	1.2	5.2	1.4	>17.9	
AVERAGE SPEED (MPH)	12.5	16.5	15.5	14.0	13.6	13.0	9.8	10.9	11.2	11.3	11.9	17.5	13.3		
AVERAGE SPEED (M/SEC)	5.6	7.4	6.9	6.3	6.1	5.8	4.4	4.9	5.0	5.1	5.3	7.8	6.0		
AVERAGE WIND POWER (WATTS/M**2)	264.5	491.5	410.5	290.0	215.6	223.5	106.6	129.8	145.4	169.1	226.3	618.3	279.8		
PERCENT DATA RECOVERY	72.3	46.5	39.4	59.0	74.4	49.2	45.6	47.8	71.1	73.6	44.4	91.7	59.6		

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 23061
PERCENTAGE DATA RECOVERY = 59.6

SOURCE: GEORESEARCH, INC.

Table IV - 44

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA C-HILL (WINTER)

01/01/76 - 05/31/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)																
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	5.9	3.8	10.4	6.9	9.4	9.4	8.3	6.9	4.9	8.0	10.1	6.9	3.8	2.8	2.4	15.0	6.7
	2	0.3	3.1	6.2	4.8	11.4	9.0	11.8	4.8	6.9	6.9	7.6	10.0	7.6	3.5	1.4	4.5	15.7	7.0
	3	0.3	2.8	7.3	6.9	9.0	12.1	9.0	9.0	8.0	6.2	4.2	9.3	4.8	4.5	2.4	4.2	15.1	6.8
	4	0.0	4.5	6.2	6.9	9.3	9.3	10.0	11.7	7.2	6.2	6.5	7.2	4.5	4.5	1.4	4.8	14.9	6.7
	5	0.3	4.8	6.5	5.5	10.6	8.9	8.6	11.0	10.6	6.2	2.1	9.6	5.5	4.1	1.4	4.5	15.0	6.7
	6	0.0	3.1	6.2	11.0	8.9	8.6	10.3	6.8	7.9	4.5	6.5	10.6	4.5	5.1	3.1	3.1	15.1	6.8
	7	0.0	4.5	6.2	10.3	11.3	6.5	13.0	7.2	8.2	2.7	5.1	9.2	5.8	4.5	1.7	3.8	14.6	6.5
	8	0.3	2.4	7.9	7.9	9.3	7.6	10.7	9.7	6.6	5.9	6.6	9.3	5.5	4.1	2.1	4.1	15.1	6.8
H	9	0.0	3.1	7.3	7.3	9.8	9.1	7.0	10.5	9.8	4.9	5.9	11.1	5.2	3.1	2.1	3.8	15.1	6.8
	10	0.3	2.1	7.7	10.1	5.6	7.7	12.5	8.4	8.4	8.7	4.9	10.5	4.5	3.5	1.0	4.2	14.9	6.7
O	11	0.0	2.1	8.3	10.1	5.9	6.9	10.1	8.3	7.3	9.7	6.9	10.8	5.2	3.8	0.7	3.8	15.1	6.8
	12	0.3	3.8	5.9	7.2	9.7	5.5	9.3	9.0	8.3	4.8	7.9	13.1	5.9	4.1	2.1	3.1	15.5	6.9
U	13	0.0	2.1	4.8	8.3	8.3	7.9	7.2	10.7	5.2	5.9	4.5	17.2	7.9	3.1	3.8	3.1	16.5	7.4
	14	0.0	2.1	5.6	5.6	7.6	10.1	7.6	7.6	6.3	6.9	6.3	16.3	9.0	2.8	3.5	2.8	16.7	7.5
R	15	0.0	3.8	2.4	6.9	10.0	7.6	8.3	6.6	4.8	8.6	6.2	14.8	10.3	6.6	0.7	2.4	16.5	7.4
	16	0.0	3.4	4.8	8.2	7.1	8.5	7.8	6.1	8.2	8.5	5.1	11.9	11.6	4.4	2.4	2.0	16.2	7.2
	17	0.0	2.7	7.8	8.1	10.5	4.7	8.1	6.8	7.5	6.1	6.8	13.2	7.1	5.8	3.1	1.7	15.6	7.0
	18	0.3	2.7	7.8	7.8	7.8	9.6	8.2	6.8	7.8	5.8	6.5	11.9	7.5	3.1	2.4	3.8	15.4	6.9
	19	0.3	2.7	9.9	6.8	7.8	8.2	8.8	8.2	7.5	5.1	6.1	8.8	9.5	6.1	2.4	1.7	15.2	6.8
	20	0.0	3.8	8.2	9.6	7.5	7.8	7.5	9.6	7.5	5.1	5.8	9.9	7.5	5.8	1.7	2.7	15.0	6.7
	21	0.0	3.1	9.2	6.4	8.1	11.2	8.5	7.1	9.5	4.4	6.1	10.2	9.5	2.7	1.0	3.1	14.8	6.6
	22	0.0	3.1	6.8	11.2	7.8	7.8	6.8	8.1	9.5	5.8	4.7	12.5	6.4	4.7	2.0	2.7	15.1	6.7
	23	0.3	3.4	5.7	7.1	7.8	9.5	10.8	11.5	6.1	4.7	2.0	13.5	6.8	6.4	2.4	2.0	15.4	6.9
	24	0.0	4.8	5.4	6.5	10.9	8.8	10.2	7.5	8.2	4.1	5.4	12.2	7.8	3.7	1.4	3.1	15.0	6.7
ALL HOURS		0.1	3.3	6.6	8.0	8.7	8.4	9.2	8.4	7.7	5.9	5.7	11.4	7.0	4.3	2.0	3.2	15.4	6.9

SOURCE: GEORESEARCH, INC.

Table IV - 45

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA C-HILL (SPRING)

01/01/76 - 05/31/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (M/SEC)																	
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	1.1	2.3	10.7	13.0	9.6	6.9	8.8	9.6	7.3	7.7	5.0	6.9	6.1	2.3	0.8	1.9	12.7	5.7
	2	0.8	3.5	8.2	10.1	11.3	10.5	9.3	9.7	5.4	7.8	5.1	10.5	3.1	2.7	1.6	0.4	12.6	5.6
	3	0.8	3.1	5.8	10.0	11.5	11.2	13.1	7.3	8.1	6.9	3.8	10.4	3.8	1.9	1.5	0.8	12.7	5.7
	4	0.8	4.9	8.3	9.8	9.5	11.0	11.0	11.4	5.3	7.2	5.7	6.8	4.9	1.9	1.1	0.4	12.2	5.5
	5	1.5	4.2	9.4	7.5	10.6	9.1	10.2	11.7	6.8	6.8	3.8	10.2	5.3	1.1	1.1	0.8	12.5	5.6
	6	1.9	6.1	7.6	8.7	9.8	10.6	11.4	7.2	9.5	5.3	5.3	8.3	4.9	2.3	0.4	0.8	12.2	5.4
	7	0.8	6.5	9.9	9.9	7.2	15.2	9.1	10.3	7.6	5.3	6.1	6.1	3.0	1.9	0.8	0.4	11.4	5.1
	8	1.1	3.4	14.9	9.2	8.8	11.9	12.6	8.0	5.0	5.4	7.7	5.0	3.4	2.3	0.4	0.8	11.4	5.1
H	9	0.8	1.9	6.9	12.0	11.6	10.8	9.7	10.8	6.2	6.9	5.0	10.4	3.9	1.9	0.4	0.8	12.5	5.6
	10	0.8	0.4	4.6	9.6	11.2	8.5	12.3	9.6	8.1	7.3	6.9	13.1	4.6	1.5	1.2	0.4	13.7	6.1
O	11	0.4	0.4	3.1	9.9	9.9	9.2	8.8	11.8	7.3	6.5	9.2	14.5	5.3	2.3	0.8	0.8	14.4	6.4
	12	0.0	0.4	3.0	5.7	7.9	9.1	12.1	10.2	9.8	8.7	6.0	15.8	8.7	0.0	1.5	1.1	15.3	6.8
U	13	0.4	1.1	1.1	5.7	8.3	9.8	8.0	7.6	10.6	11.0	6.8	15.5	10.6	1.9	0.4	1.1	15.9	7.1
	14	0.0	0.8	2.7	5.7	7.2	6.8	8.7	9.5	9.8	8.7	8.0	18.2	9.5	2.3	0.4	1.9	16.4	7.3
R	15	0.0	0.0	2.6	4.9	7.2	9.1	7.9	10.2	7.2	9.1	13.6	13.2	8.7	3.8	1.9	0.8	16.5	7.4
	16	0.0	0.0	2.2	4.4	9.3	8.5	8.1	8.5	6.3	9.3	7.4	20.7	8.1	5.9	0.4	0.7	16.7	7.5
	17	0.0	0.4	2.6	4.8	4.5	8.9	8.6	7.1	6.7	9.3	8.9	22.3	9.3	4.5	1.9	0.4	17.2	7.7
	18	0.0	0.4	2.6	4.5	7.5	6.3	10.4	9.3	4.5	7.8	14.6	16.0	10.8	3.0	1.5	0.7	16.8	7.5
	19	0.0	1.1	1.9	3.0	10.4	10.4	5.6	9.0	10.8	8.2	8.6	19.0	6.0	2.2	1.9	1.9	16.3	7.3
	20	0.0	0.0	4.1	6.0	11.2	6.7	8.6	7.8	10.4	7.1	8.6	15.7	7.8	3.7	0.7	1.5	15.8	7.1
	21	0.4	0.7	3.7	8.9	10.4	9.7	11.2	7.4	7.1	7.4	8.2	14.1	4.8	3.0	2.6	0.4	14.8	6.6
	22	0.7	0.7	8.6	12.6	8.6	9.3	9.3	5.6	5.9	8.2	5.6	14.5	6.3	2.2	1.1	0.7	13.7	6.1
	23	1.1	3.0	9.3	10.7	9.3	10.4	11.5	5.6	5.2	8.1	4.4	11.1	5.9	1.9	1.5	1.1	13.0	5.8
	24	0.7	1.5	10.0	10.0	7.8	13.3	7.0	8.1	8.1	5.9	4.8	13.7	3.7	3.3	1.1	0.7	13.2	5.9
ALL HOURS		0.6	1.9	6.0	8.2	9.2	9.7	9.7	8.9	7.5	7.6	7.0	13.0	6.2	2.5	1.1	0.9	14.2	6.3

SOURCE: GEORESEARCH, INC.

Table IV - 46

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA C-HILL (SUMMER)

01/01/76 - 05/31/79

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	5.7	11.4	13.6	14.8	14.2	14.2	7.4	7.4	4.0	2.3	4.0	0.6	0.0	0.0	0.6	9.1	4.1
	2	0.0	4.0	11.5	19.5	14.9	15.5	9.2	8.6	4.0	4.0	2.3	4.6	1.1	0.6	0.0	0.0	8.9	4.0
	3	0.6	4.0	14.2	17.0	17.6	13.1	10.8	7.4	4.0	5.7	1.7	1.7	1.7	0.6	0.0	0.0	8.5	3.8
	4	1.7	4.0	14.9	20.6	13.7	13.1	6.3	9.1	5.7	3.4	2.3	4.0	1.1	0.0	0.0	0.0	8.3	3.7
	5	1.1	6.9	16.6	15.4	17.7	8.0	9.7	8.0	5.7	5.1	1.1	3.4	0.0	1.1	0.0	0.0	8.1	3.6
	6	0.6	6.8	17.0	21.6	8.5	10.2	9.1	10.2	6.8	2.3	2.8	1.7	1.7	0.0	0.6	0.0	8.2	3.7
	7	1.7	9.2	17.8	18.4	13.2	11.5	9.2	6.3	3.4	4.0	0.6	2.9	1.7	0.0	0.0	0.0	7.5	3.3
	8	0.0	6.3	15.3	19.3	18.2	14.8	10.2	4.5	2.8	1.7	1.1	4.0	1.7	0.0	0.0	0.0	7.9	3.5
H	9	0.0	2.3	14.2	21.6	16.5	9.7	10.8	9.7	3.4	5.7	0.6	4.0	1.1	0.6	0.0	0.0	8.7	3.9
	10	0.0	1.8	8.8	22.2	15.2	12.9	10.5	9.4	4.1	5.3	2.9	5.3	1.2	0.6	0.0	0.0	9.4	4.2
O	11	0.0	0.0	6.3	16.7	18.4	11.5	11.5	10.9	6.9	6.3	4.0	5.2	1.1	0.6	0.0	0.6	10.5	4.7
	12	0.0	1.1	3.4	8.6	17.1	11.4	12.6	12.6	8.0	4.6	8.0	8.0	3.4	1.1	0.0	0.0	12.1	5.4
U	13	0.0	0.0	3.4	9.0	13.6	13.6	11.9	8.5	6.8	6.2	6.8	14.1	4.0	1.1	1.1	0.0	13.3	5.9
	14	0.0	0.0	1.7	5.2	14.0	16.9	10.5	5.2	8.1	7.6	8.7	13.4	6.4	1.2	1.2	0.0	14.1	6.3
R	15	0.0	0.0	1.7	4.0	13.1	17.1	10.9	9.7	5.7	4.0	5.7	14.9	9.1	2.9	0.6	0.6	14.7	6.6
	16	0.0	0.0	1.1	2.9	12.6	10.3	10.9	12.1	6.9	8.6	8.6	14.9	5.2	2.9	2.9	0.0	15.5	6.9
	17	0.0	0.6	1.7	6.9	5.2	14.5	11.6	8.7	10.4	5.2	6.9	15.0	9.2	1.7	2.3	0.0	15.4	6.9
	18	0.0	1.1	2.3	5.7	9.7	10.3	12.6	11.4	6.3	6.9	5.1	17.1	7.4	2.3	1.1	0.6	15.1	6.7
	19	0.0	0.0	4.5	4.5	10.7	12.4	13.6	9.0	9.0	7.3	5.1	11.9	6.8	4.0	0.0	1.1	14.5	6.5
	20	0.0	0.6	2.3	8.6	10.9	16.1	9.8	10.3	6.9	5.7	6.9	12.6	6.3	1.7	0.6	0.6	13.8	6.2
	21	0.0	1.7	5.2	14.4	9.2	13.8	9.8	8.0	8.0	8.0	5.7	10.9	2.9	0.6	1.1	0.6	12.5	5.6
	22	0.0	1.7	8.0	12.5	13.6	11.9	9.1	8.0	9.1	6.8	4.5	8.5	4.0	1.7	0.6	0.0	11.8	5.3
	23	0.0	2.8	9.7	9.7	15.3	13.6	12.5	6.3	3.4	8.5	5.7	6.8	2.3	2.3	0.6	0.6	11.4	5.1
	24	0.0	2.9	10.3	17.2	14.9	9.2	9.2	10.3	6.9	6.9	2.3	8.0	0.6	0.6	0.0	0.6	10.2	4.6
ALL HOURS		0.2	2.6	8.5	13.1	13.7	12.7	10.7	8.8	6.2	5.6	4.2	8.2	3.4	1.2	0.5	0.2	11.2	5.0

SOURCE: GEORESEARCH, INC.

Table IV - 47

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA C-HILL (AUTUMN)

01/01/76 - 05/31/79

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.4	7.0	14.8	15.2	11.3	11.3	8.7	7.8	5.7	5.2	1.3	7.0	1.3	1.7	0.9	0.4	9.9	4.4
	2	1.7	6.1	12.2	14.3	13.0	10.0	9.1	11.7	3.9	4.8	2.2	6.1	2.2	1.7	0.4	0.4	9.9	4.4
	3	0.4	4.3	10.0	18.3	11.7	13.5	9.6	6.5	7.4	7.0	3.5	5.2	1.7	0.0	0.4	0.4	9.9	4.4
	4	0.9	5.7	13.0	15.7	15.7	9.6	10.0	5.2	5.2	5.7	3.9	6.1	2.6	0.0	0.4	0.4	9.7	4.3
	5	1.7	4.8	13.9	10.9	14.3	11.3	8.7	8.3	6.5	3.9	4.3	6.1	2.6	1.3	0.9	0.4	10.3	4.6
	6	0.4	6.1	14.5	8.8	12.3	11.0	12.3	9.6	5.7	5.7	3.5	5.3	2.2	1.3	0.0	1.3	10.5	4.7
	7	1.8	8.0	9.8	11.1	18.2	11.6	8.0	7.6	6.7	3.6	3.6	7.6	0.9	0.4	0.9	0.4	9.8	4.4
	8	0.0	7.9	13.1	12.2	10.0	12.7	8.3	10.0	7.0	4.8	2.6	7.4	2.2	0.9	0.4	0.4	10.1	4.5
H	9	0.0	7.4	13.9	10.4	10.9	13.9	10.9	4.3	6.5	6.5	2.2	10.0	1.3	0.9	0.9	0.0	10.3	4.6
	10	0.0	4.4	7.9	11.0	14.5	11.0	11.9	9.3	8.4	4.0	5.7	7.5	2.6	0.4	0.4	0.9	11.3	5.1
O	11	0.0	1.8	5.7	10.1	11.4	11.0	12.3	10.1	11.0	7.5	7.0	7.5	3.1	1.3	0.0	0.4	12.2	5.5
	12	0.0	0.0	6.1	9.2	11.8	11.0	8.8	13.2	9.6	9.6	3.5	13.2	2.6	0.4	0.9	0.0	12.8	5.7
U	13	0.0	0.4	7.5	7.1	11.1	11.5	12.4	8.4	10.2	8.0	6.6	12.4	1.8	1.3	0.9	0.4	13.1	5.8
	14	0.0	0.4	6.3	10.3	8.0	10.7	9.4	12.1	8.9	7.1	5.8	13.8	4.9	0.4	0.9	0.9	13.7	6.1
R	15	0.0	1.3	3.9	10.1	12.7	10.1	9.6	9.2	5.7	7.9	8.8	14.9	3.1	1.8	0.9	0.0	13.5	6.0
	16	0.0	1.3	5.6	9.1	13.8	10.3	7.8	5.6	8.2	6.0	9.9	16.4	3.4	1.7	0.4	0.4	13.6	6.1
	17	0.4	2.6	5.6	9.1	11.6	9.5	8.6	7.3	6.5	12.1	7.3	10.8	6.0	1.7	0.0	0.9	13.3	6.0
	18	0.4	1.7	7.4	10.0	10.4	9.1	13.4	7.4	6.1	7.8	6.5	11.3	5.6	2.6	0.0	0.4	13.1	5.9
	19	0.4	0.9	9.0	13.3	11.2	7.7	11.2	7.7	9.0	8.2	4.3	12.9	3.0	0.4	0.0	0.9	12.2	5.5
	20	0.9	2.1	9.4	14.2	9.0	9.0	11.2	7.7	9.4	5.6	5.2	9.0	4.3	2.1	0.9	0.0	12.0	5.4
	21	0.4	4.3	11.6	15.5	9.9	6.0	7.3	9.9	9.4	6.9	5.6	8.6	1.3	2.6	0.9	0.0	11.3	5.1
	22	0.9	4.3	14.5	11.1	13.2	8.1	10.3	9.0	7.7	4.3	2.1	9.4	1.7	1.7	1.3	0.4	10.8	4.8
	23	0.9	3.8	13.7	16.2	10.7	10.7	9.4	9.0	6.8	5.6	3.8	4.3	3.0	0.9	0.4	0.9	10.3	4.6
	24	0.9	2.6	15.8	13.2	12.4	11.5	9.8	9.0	7.3	3.8	2.1	6.8	2.6	1.7	0.4	0.0	10.2	4.6
ALL HOURS		0.5	3.7	10.2	11.9	12.0	10.5	9.9	8.6	7.4	6.3	4.6	9.1	2.8	1.2	0.6	0.5	11.4	5.1

SOURCE: GEORESEARCH, INC.

Table IV - 48

Annual Wind Rose Distribution

DEER LODGE COUNTY - ANACONDA C-HILL

01/01/76 - 05/31/79

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	1.5	0.1- 0.4
1.1- 2.0	0.0	0.0	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.1	0.0	0.1	2.7	0.5- 0.9
2.1- 3.0	0.0	0.1	0.2	0.2	0.3	0.3	0.2	0.2	0.4	0.3	0.4	0.3	0.3	0.2	0.1	0.1	3.7	1.0- 1.3
3.1- 4.0	0.0	0.1	0.2	0.2	0.3	0.5	0.3	0.3	0.4	0.5	0.5	0.4	0.4	0.2	0.1	0.1	4.3	1.4- 1.8
4.1- 5.0	0.0	0.1	0.2	0.3	0.3	0.4	0.2	0.2	0.5	0.5	0.6	0.5	0.4	0.3	0.2	0.1	4.8	1.9- 2.2
5.1- 6.0	0.0	0.0	0.2	0.3	0.3	0.4	0.3	0.2	0.4	0.6	0.6	0.7	0.5	0.3	0.1	0.1	5.3	2.3- 2.7
6.1- 7.0	0.0	0.0	0.3	0.3	0.3	0.4	0.2	0.3	0.5	0.6	0.6	0.6	0.6	0.4	0.1	0.0	5.3	2.8- 3.1
7.1- 8.0	0.0	0.0	0.2	0.3	0.2	0.4	0.2	0.2	0.4	0.6	0.7	0.6	0.6	0.4	0.1	0.0	5.1	3.2- 3.6
8.1- 9.0	0.0	0.0	0.2	0.2	0.1	0.3	0.2	0.2	0.5	0.7	0.6	0.5	0.7	0.5	0.2	0.1	5.2	3.7- 4.0
9.1-10.0	0.0	0.0	0.1	0.1	0.1	0.3	0.2	0.2	0.5	0.9	0.6	0.5	0.7	0.4	0.1	0.0	4.9	4.1- 4.5
10.1-11.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.5	0.9	0.7	0.5	0.9	0.4	0.2	0.0	4.9	4.6- 4.9
11.1-12.0	0.0	0.0	0.1	0.0	0.1	0.2	0.2	0.2	0.5	0.7	0.6	0.4	0.9	0.4	0.2	0.0	4.6	5.0- 5.4
12.1-13.0	0.0	0.0	0.1	0.0	0.0	0.2	0.1	0.2	0.5	0.8	0.6	0.4	0.9	0.4	0.2	0.0	4.4	5.5- 5.8
13.1-14.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.7	0.5	0.3	0.9	0.3	0.1	0.0	4.0	5.9- 6.3
14.1-15.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.5	0.7	0.5	0.4	0.8	0.3	0.1	0.0	3.7	6.4- 6.7
15.1-16.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.4	0.5	0.4	0.3	1.0	0.3	0.1	0.0	3.4	6.8- 7.2
16.1-17.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.6	0.4	0.3	0.9	0.3	0.1	0.0	3.2	7.3- 7.6
17.1-18.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.5	0.4	0.3	0.9	0.3	0.1	0.0	3.0	7.7- 8.0
18.1-19.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.5	0.3	0.3	1.1	0.2	0.0	0.0	2.9	8.1- 8.5
19.1-20.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.4	0.3	0.2	0.9	0.2	0.1	0.0	2.5	8.6- 8.9
20.1-25.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.6	1.5	1.0	1.0	4.2	0.7	0.2	0.0	9.7	9.0-11.2
25.1-30.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.8	0.6	0.5	2.6	0.3	0.1	0.0	5.2	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.3	1.3	0.1	0.0	0.0	2.6	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.7	0.0	0.0	0.0	1.1	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.7	0.0	0.0	0.0	1.4	>17.9
CALM																	0.4	CALM
TOTAL	0.4	0.4	2.2	2.6	2.7	5.4	3.6	3.8	8.8	14.3	11.9	9.9	23.1	7.2	2.5	0.7	100.0	TOTAL
AV SPD (MPH)	5.6	5.3	6.9	6.1	6.1	9.3	9.4	9.8	11.3	14.2	13.7	14.1	18.7	12.9	12.6	6.3	13.4	AV SPD (MPH)
AV SPD (M/S)	2.5	2.4	3.1	2.7	2.7	4.2	4.2	4.4	5.1	6.4	6.1	6.3	8.4	5.7	5.6	2.8	6.0	AV SPD (M/S)

SOURCE: GEORESEARCH, INC.

Figure IV - 5
Annual Wind Rose
ANACONDA C-HILL — DEER LODGE COUNTY
(1976 - 1979)

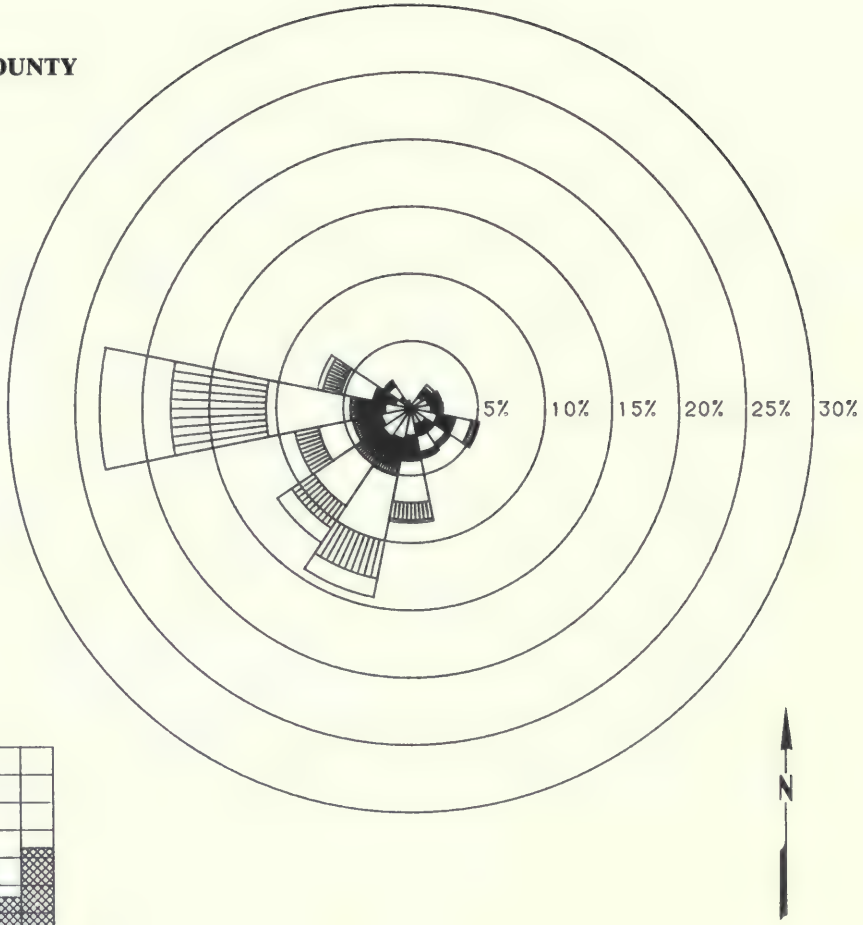


Table IV - 49

Coefficients of Weibull Distribution

DEER LODGE COUNTY - ANACONDA C-HILL

01/01/76 - 05/31/79

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	6.2265	1.5942
FEBRUARY	8.7423	1.4705
MARCH	7.8791	1.7362
APRIL	7.2504	1.5403
MAY	6.9668	1.8666
JUNE	6.1791	1.7193
JULY	4.6619	1.6962
AUGUST	5.2224	1.8563
SEPTEMBER	5.7329	1.6344
OCTOBER	5.6493	1.5167
NOVEMBER	5.7649	1.5737
DECEMBER	8.5135	1.6476
YEAR	6.5641	1.5997

SOURCE: GEORESEARCH, INC.

ANACONDA HIGHWAY JUNCTION

DEER LODGE COUNTY

The Highway Junction site was located approximately 3 miles north of Anaconda at 46 08 09 N and 112 53 17 W (Site No. 29 on Map II-1). Elevation at the site was 5,100 feet. The site was established by the Montana Air Quality Bureau to measure concentrations of sulfur dioxide in the area.

Wind data were collected at the site from June 11, 1975, to December 28, 1979. Data through August 27, 1979, were analyzed for this *Atlas*. The data set contains hourly averages of wind speed and direction manually reduced from stripchart records. When monitoring at this site began, data were gathered by a Meteorology Research, Inc., mechanical recording unit. Beginning in 1978, data were collected by a Climatronics electronic anemometer and wind vane on a 10-meter tower.

Winds were monitored long enough at this site to adequately represent the wind resource. Wind data from this location are representative of a limited area near the site since it is located near the mouth of a large canyon to the west.

Data recovery ranged from 47.7 percent in December to 98.3 percent in March. Overall data recovery was 79.5 percent.

Average annual wind speed at the site was 8.0 miles per hour. Average monthly wind speeds ranged from 6.8 miles per hour in July to 9.3 miles per hour in November.

Average monthly wind power ranged from 26.9 watts/m^2 in July to 120.5 watts/m^2 in November. Average annual wind power was 62.8 watts/m^2.

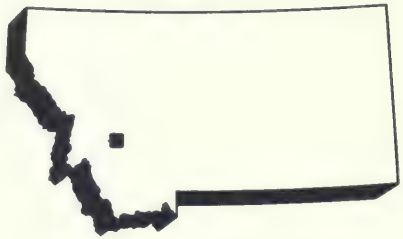


Table IV - 50

Monthly Wind Speed Distribution

DEER LODGE COUNTY - ANACONDA HIGHWAY JUNCTION

06/11/75 - 08/27/79

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	0.5	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.3	0.2	0.0	0.1
0.1-1.0	0.9	0.7	0.6	0.2	0.1	0.2	0.1	0.1	0.2	0.4	1.1	0.4	0.4
1.1-2.0	9.9	4.4	3.3	3.4	2.2	2.2	3.1	2.4	3.1	4.8	6.3	6.0	4.0
2.1-3.0	15.1	8.8	7.5	7.1	7.4	6.4	7.4	8.2	9.1	10.1	9.3	11.6	8.7
3.1-4.0	12.1	9.2	9.6	9.3	7.8	7.7	9.5	8.6	9.1	9.0	8.9	9.3	9.1
4.1-5.0	11.1	8.4	7.9	9.1	8.2	8.6	10.3	10.8	8.0	9.7	7.4	8.0	9.0
5.1-6.0	5.9	6.7	8.1	9.2	7.7	8.3	10.8	9.4	9.7	8.9	6.0	6.7	8.3
6.1-7.0	5.1	6.5	7.7	9.3	8.4	10.2	11.6	10.7	11.1	8.3	5.1	5.8	8.6
7.1-8.0	3.7	5.9	6.9	8.4	7.9	10.0	10.4	10.9	9.6	7.3	5.2	4.4	7.9
8.1-9.0	3.8	4.6	6.9	7.1	7.6	8.6	9.3	9.0	8.2	6.7	4.7	3.2	6.9
9.1-10.0	3.4	3.7	4.6	5.7	6.7	8.0	8.5	8.3	7.7	5.7	3.9	3.3	6.0
10.1-11.0	3.2	3.8	4.4	5.7	6.4	6.2	5.8	5.9	6.5	5.6	3.4	3.0	5.1
11.1-12.0	3.0	4.0	4.8	4.6	6.0	3.8	4.3	4.2	5.1	4.3	4.4	3.3	4.4
12.1-13.0	2.9	3.3	4.4	3.7	3.9	3.4	3.2	2.9	3.3	3.8	4.4	3.6	3.6
13.1-14.0	1.8	4.0	3.9	3.8	4.4	2.7	1.8	2.0	2.1	3.5	3.3	3.9	3.1
14.1-15.0	1.5	3.4	3.2	3.8	3.1	2.9	1.3	1.9	1.8	2.6	4.5	3.5	2.7
15.1-16.0	1.9	3.9	3.3	2.2	2.9	2.7	0.9	1.0	1.5	2.5	4.1	4.3	2.5
16.1-17.0	1.5	3.3	3.3	2.3	2.4	1.8	0.5	1.0	1.5	1.7	3.5	3.4	2.1
17.1-18.0	1.3	3.5	2.4	1.6	2.1	2.0	0.5	1.0	1.0	1.3	2.9	2.8	1.8
18.1-19.0	1.9	2.1	1.8	1.2	1.3	1.4	0.3	0.8	0.7	1.1	1.7	2.1	1.3
19.1-20.0	1.6	1.9	1.6	1.0	1.4	0.7	0.3	0.4	0.2	0.9	1.6	2.3	1.1
20.1-25.0	4.3	6.5	3.1	1.2	1.8	1.9	0.3	0.6	0.4	1.4	4.4	7.0	2.5
25.1-30.0	2.7	1.0	0.4	0.0	0.0	0.2	0.1	0.0	0.0	0.0	2.9	2.0	0.6
30.1-35.0	0.8	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.1
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	7.7	9.3	8.6	7.9	8.4	8.1	6.8	7.1	7.2	7.5	9.5	9.4	8.0
AVERAGE SPEED (M/SEC)	3.4	4.2	3.8	3.5	3.8	3.6	3.0	3.2	3.2	3.3	4.2	4.2	3.6
AVERAGE WIND POWER (WATTS/M**2)	102.8	103.8	72.4	51.6	57.0	52.1	26.9	32.5	34.7	46.6	120.5	117.2	62.8
PERCENT DATA RECOVERY	69.4	91.7	98.3	95.1	86.8	76.0	93.9	78.2	74.1	70.8	69.8	47.7	79.5

SPEED (MPH)

CALM	
0.1- 0.4	
0.5- 0.9	
1.0- 1.3	
1.4- 1.8	
1.9- 2.2	
2.3- 2.7	
2.8- 3.1	
3.2- 3.6	
3.7- 4.0	
4.1- 4.5	
4.6- 4.9	
5.0- 5.4	
5.5- 5.8	
5.9- 6.3	
6.4- 6.7	
6.8- 7.2	
7.3- 7.6	
7.7- 8.0	
8.1- 8.5	
8.6- 8.9	
9,0-11.2	
11.3-13.4	
13.5-15.6	
15.7-17.9	
>17.9	

SPEED (M/SEC)

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ANACONDA MILL CREEK

DEER LODGE COUNTY

The Mill Creek site was located approximately 4 miles east-southeast of Anaconda at 46 06 19 N and 112 52 45 W (Site No. 31 on Map II-1). Elevation at the site was 5,199 feet. The site was established by the Anaconda Copper Company to measure concentrations of particulates and sulfur dioxide in the area.

Wind data from December 4, 1976, through May 31, 1979, were collected at the site. Data through February 28, 1979, were analyzed for this *Atlas*. The data set consists of hourly averages of wind speed and wind direction manually reduced from stripchart records. Data recovery was fair to excellent, ranging from 41.1 percent in November to 97.5 percent in October. Overall data recovery was 70.0 percent. Winds were monitored long enough at this site to adequately represent the wind resource. The anemometer height was 10 meters. Because the site is located in complex terrain, the data are representative only of a limited area. DNRC-sponsored monitoring underway in 1986 and 1987 suggests wind speeds are greater closer to the mouth of the Mill Creek Valley.

Average annual wind speed at this site was 9.5 miles per hour. Average monthly wind speeds ranged from 7.4 miles per hour in July to 13.0 miles per hour in December.

Average monthly wind power ranged from 33.1 watts/m^2 in July to 211.5 watts/m^2 in December. Average annual wind power was 95.2 watts/m^2.

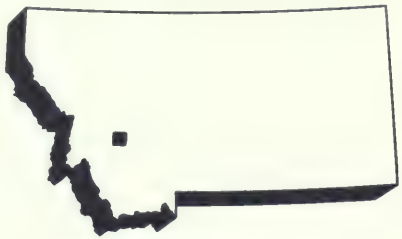


Table IV - 51

Monthly Wind Speed Distribution

DEER LODGE COUNTY - ANACONDA MILL CREEK

12/04/76 - 02/28/79

WIND SPEED (MPH) / HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	WIND SPEED (MPH) / HOUR
CALM	4.1	2.6	3.7	0.5	0.2	0.4	0.5	0.7	0.1	0.1	3.7	0.4	1.3	CALM
0.1-1.0	4.7	6.0	4.0	3.5	2.9	3.0	1.8	1.8	1.8	1.9	6.9	2.6	3.3	0.1- 0.4
1.1-2.0	5.8	5.2	3.3	3.7	4.3	3.3	4.2	3.8	3.8	3.5	8.1	3.5	4.3	0.5- 0.9
SPEED 2.1-3.0	6.1	5.8	3.9	6.2	5.2	5.1	4.4	6.0	4.1	3.7	7.4	3.6	5.0	1.0- 1.3
3.1-4.0	5.7	6.0	4.3	5.2	7.0	6.4	6.5	5.3	5.3	4.4	6.9	3.2	5.3	1.4- 1.8
4.1-5.0	6.7	6.3	4.7	6.7	6.7	8.5	9.5	5.3	7.5	7.0	4.9	3.1	6.2	1.9- 2.2
5.1-6.0	5.4	6.5	5.6	8.0	7.3	8.4	12.1	10.0	7.6	7.7	4.4	3.6	6.8	2.3- 2.7
6.1-7.0	5.9	8.1	6.1	6.3	8.4	12.4	10.2	10.2	8.9	8.4	5.2	3.8	7.3	2.8- 3.1
7.1-8.0	5.8	4.6	6.6	10.2	8.1	10.4	10.7	12.7	10.2	8.3	2.9	4.6	7.7	3.2- 3.6
MILES 8.1-9.0	5.3	5.1	7.0	7.7	7.0	8.0	10.8	8.9	9.1	7.2	3.7	3.6	6.6	3.7- 4.0
PER 9.1-10.0	4.5	2.9	3.3	7.5	6.7	9.0	8.4	8.8	9.1	6.1	3.7	4.3	6.1	4.1- 4.5
HOUR 10.1-11.0	2.9	3.4	5.4	6.9	7.7	5.1	6.0	5.3	5.8	5.0	1.7	4.2	5.0	4.6- 4.9
11.1-12.0	3.3	5.2	4.7	5.2	5.8	4.8	4.0	4.2	5.6	4.3	3.5	3.7	4.5	5.0- 5.4
12.1-13.0	2.0	3.3	4.4	4.5	4.2	3.8	2.1	2.3	3.6	5.9	3.4	4.9	3.9	5.5- 5.8
13.1-14.0	2.8	4.9	5.1	4.0	3.9	2.6	3.2	2.5	3.9	3.8	2.7	4.4	3.7	5.9- 6.3
14.1-15.0	3.1	3.6	4.3	3.8	3.9	3.0	1.3	1.8	2.7	4.2	3.0	5.1	3.6	6.4- 6.7
15.1-16.0	2.9	3.4	3.7	3.3	3.3	1.8	1.3	1.5	2.8	4.7	3.5	5.1	3.4	6.8- 7.2
16.1-17.0	3.9	3.8	3.3	1.4	2.6	1.1	1.3	3.5	2.1	2.7	3.7	4.8	3.0	7.3- 7.6
17.1-18.0	4.0	2.2	4.3	1.7	1.9	1.0	0.2	1.9	1.8	1.9	2.9	3.9	2.5	7.7- 8.0
18.1-19.0	2.7	2.8	1.9	1.3	1.1	0.3	0.8	1.8	1.4	2.1	4.2	3.6	2.1	8.1- 8.5
19.1-20.0	2.6	2.1	2.5	1.0	0.7	0.7	0.3	1.0	1.2	2.3	3.0	4.0	2.0	8.6- 8.9
20.1-25.0	8.2	4.9	6.6	1.1	0.9	0.9	0.3	0.7	1.6	4.3	8.6	14.7	5.2	9.0-11.2
25.1-30.0	1.5	1.2	1.4	0.1	0.1	0.0	0.0	0.0	0.1	0.5	1.5	4.1	1.1	11.3-13.4
30.1-35.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	0.1	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	9.5	9.1	10.1	8.4	8.4	7.7	7.4	8.1	8.6	9.6	9.4	13.0	9.5	
AVERAGE SPEED (M/SEC)	4.2	4.1	4.5	3.7	3.8	3.4	3.3	3.6	3.8	4.3	4.2	5.8	4.2	
AVERAGE WIND POWER (WATTS/M**2)	120.8	99.0	114.0	57.1	55.7	40.7	33.1	48.2	57.4	85.0	123.4	211.5	95.2	
PERCENT DATA RECOVERY	85.7	44.1	48.8	97.9	89.9	48.8	41.5	45.9	97.3	97.5	41.1	93.0	70.0	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 13730
PERCENTAGE DATA RECOVERY = 70.0

SOURCE: GEORESEARCH, INC.

ANACONDA WEATHER HILL

DEER LODGE COUNTY

The Weather Hill air monitoring site was located approximately 2 miles southeast of Anaconda at 46 05 51 N and 112 54 51 W (Site No. 33 on Map II-1). Elevation at the site was 6,378 feet. The site is owned by Anaconda Copper Company. The air monitoring station was established by the company to monitor concentrations of particulates and sulfur dioxide.

The land around the site is very rugged. To the southwest, the Anaconda Range rises to more than 11,000 feet. To the north is the Flint Creek Range, with summits over 10,000 feet. The area is dissected by many deep canyons.

In general, land in the valleys is privately owned, while land in the mountains is controlled by the U.S. Forest Service. Several major electrical transmission lines cross the Deer Lodge Valley. The nearest commercial airport is the Anaconda airport, located northeast of the site.

Wind data for December 4, 1976, through May 31, 1979, were available for analysis. The data set consists of hourly averages of wind speed and wind direction manually reduced from stripchart records. Anemometer height was 10 meters.

Data recovery varied from 32.6 percent in March to 97.3 percent in September. Overall data recovery was 63.6 percent. Winds were monitored long enough to adequately represent the wind resource at this location. Because of the region's complex terrain, however, the data are representative only of the area near the site, which is on a narrow ridge crest. The rugged nature of the site limits the possibilities for development.

Average annual wind speed at this site was 17.0 miles per hour. Average monthly wind speed ranged from 11.7 miles per hour in July to 23.9 miles per hour in December.

Average annual wind power was 517.4 watts/m^2. Average monthly wind power ranged from 197.1 watts/m^2 in July to 1,147.7 watts/m^2 in December.

Average seasonal wind speeds were 13.1 miles per hour in summer, 16.0 miles per hour in autumn, 16.7 miles per hour in spring, and 19.8 miles per hour in winter. Average wind speeds were highest around noon during the winter. During the other seasons the highest average wind speeds occurred from mid to late afternoon. The lowest average wind speeds occurred in the early evening in autumn and winter, around midnight in spring, and after dawn during the summer.

The diurnal range of average hourly wind speeds was greatest in the summer and least in the winter. Most of the variation in average wind speeds among the seasons was due to differences in the average nighttime wind speed.

The most common wind direction was west-southwest. Winds blew from this direction 40 percent of the time. Winds from the west and west-northwest blew 21.6 percent of the time. The least common wind directions were north-northwest through north-northeast.

Average wind speeds by direction ranged from 5.9 miles per hour from the east to 21.9 miles per hour from the west-southwest. The strongest winds were those from the prevailing wind directions.

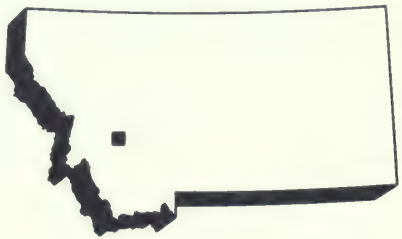


Table IV - 52

Monthly Wind Speed Distribution

DEER LODGE COUNTY - ANACONDA WEATHER HILL

12/04/76 - 05/31/79

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM	0.1	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.3	0.3	0.8	0.0	0.1	CALM	
0.1-1.0	1.8	2.0	1.4	1.2	0.9	2.0	1.5	2.2	1.9	1.2	2.9	0.8	1.5	0.1- 0.4	
1.1-2.0	2.7	3.6	2.6	2.2	1.2	1.8	3.4	4.7	2.1	3.1	4.1	1.6	2.4	0.5- 0.9	S
S 2.1-3.0	3.3	4.5	2.9	2.6	1.6	3.0	6.3	3.1	1.7	3.6	4.5	1.5	2.8	1.0- 1.3	P
P 3.1-4.0	4.5	3.3	3.3	3.2	2.5	2.0	5.8	4.6	3.1	3.0	7.0	1.5	3.3	1.4- 1.8	E
E 4.1-5.0	3.6	3.1	2.5	3.3	3.4	3.0	7.3	4.7	2.8	2.8	4.5	2.4	3.4	1.9- 2.2	E
E 5.1-6.0	3.7	2.7	3.0	3.9	3.0	5.3	7.0	4.1	3.1	4.9	5.2	1.3	3.5	2.3- 2.7	D
D 6.1-7.0	3.3	3.4	3.6	3.8	3.5	7.0	6.0	6.0	3.1	3.3	6.8	2.0	3.8	2.8- 3.1	
7.1-8.0	3.2	3.7	3.6	4.4	3.4	5.7	5.2	4.9	2.9	3.5	4.7	1.7	3.5	3.2- 3.6	M
M 8.1-9.0	2.6	2.6	2.6	3.3	3.5	3.6	4.2	4.0	4.4	3.4	2.1	1.8	3.1	3.7- 4.0	E
I 9.1-10.0	2.8	2.7	2.1	3.5	3.6	4.4	4.4	4.0	3.6	3.5	3.3	2.0	3.2	4.1- 4.5	T
L 10.1-11.0	3.3	3.1	3.4	4.3	3.5	4.4	4.4	4.7	4.3	2.7	2.3	1.4	3.4	4.6- 4.9	E
E 11.1-12.0	2.8	3.6	2.1	4.4	2.5	4.4	4.5	4.0	4.0	3.2	1.4	1.3	3.1	5.0- 5.4	R
S 12.1-13.0	3.1	3.9	1.0	4.0	3.3	4.1	3.8	2.1	4.2	4.2	1.7	1.8	3.1	5.5- 5.8	S
/ 13.1-14.0	2.8	3.4	2.9	4.6	4.2	5.3	3.8	4.6	4.4	4.4	1.7	1.7	3.6	5.9- 6.3	/
H 14.1-15.0	2.3	3.8	2.9	3.2	4.0	4.5	2.3	3.8	4.3	3.0	2.7	1.8	3.2	6.4- 6.7	S
O 15.1-16.0	2.2	2.0	2.8	4.1	4.6	4.0	2.6	2.9	5.1	2.8	1.9	3.2	3.4	6.8- 7.2	E
U 16.1-17.0	3.0	2.7	2.9	3.4	4.1	4.7	1.6	4.4	3.3	2.2	1.7	2.3	3.1	7.3- 7.6	C
R 17.1-18.0	3.0	2.6	2.8	3.5	3.5	4.0	3.1	3.4	4.1	3.6	1.4	2.7	3.2	7.7- 8.0	O
18.1-19.0	3.1	2.7	3.4	3.0	4.0	4.1	1.7	2.1	2.2	3.6	1.2	3.3	3.0	8.1- 8.5	N
19.1-20.0	3.2	3.4	4.5	4.0	3.1	2.0	3.6	3.1	3.4	3.5	2.1	2.5	3.2	8.6- 8.9	D
20.1-25.0	15.8	10.6	15.3	13.0	16.7	8.8	9.3	10.5	14.2	13.6	9.3	14.6	13.6	9,0-11.2	
25.1-30.0	12.2	9.4	12.9	8.9	12.0	4.8	5.2	7.1	10.4	12.9	10.1	14.4	10.8	11.3-13.4	
30.1-35.0	5.9	8.0	6.3	4.5	5.5	4.7	2.0	3.8	5.6	4.7	7.6	12.7	6.3	13.5-15.6	
35.1-40.0	3.3	5.7	5.4	2.3	2.0	1.6	0.4	0.7	1.1	2.6	6.2	10.0	3.7	15.7-17.9	
>40.0	2.4	3.4	3.7	1.4	0.4	1.0	0.4	0.6	0.6	0.7	2.9	9.8	2.6	>17.9	
AVERAGE SPEED (MPH)	17.0	17.4	18.5	15.7	16.8	14.1	11.7	13.4	16.0	16.0	15.8	23.9	17.0		
AVERAGE SPEED (M/SEC)	7.6	7.8	8.3	7.0	7.5	6.3	5.2	6.0	7.1	7.2	7.1	10.7	7.6		
AVERAGE WIND POWER (WATTS/M**2)	542.2	610.1	635.4	396.5	403.6	301.9	197.1	260.7	383.1	404.9	564.2	1147.7	517.4		
PERCENT DATA RECOVERY	86.1	44.1	32.6	65.3	93.4	48.9	46.1	45.6	97.3	67.5	35.8	86.0	63.6		

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 13882
PERCENTAGE DATA RECOVERY = 63.6

SOURCE: GEORESEARCH, INC.

Table IV - 53

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA WEATHER HILL (WINTER)

12/04/76 - 05/31/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)																
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	5.2	5.2	7.3	3.6	2.1	4.2	6.3	5.2	7.3	4.7	18.2	14.1	8.3	5.2	3.1	19.4	8.7
	2	0.0	6.2	5.7	3.6	3.6	4.7	7.3	4.1	4.7	3.1	5.2	17.1	15.5	8.3	4.7	6.2	20.1	9.0
	3	0.0	5.2	5.7	5.2	3.1	3.6	5.7	3.6	7.8	4.7	5.2	19.2	10.4	9.3	5.2	6.2	19.9	8.9
	4	0.0	4.1	5.2	5.7	2.6	3.6	6.7	5.2	4.7	5.7	5.7	16.6	15.5	7.3	6.2	5.2	20.2	9.0
	5	0.0	4.6	6.2	1.0	5.6	5.6	3.1	6.2	6.7	7.7	9.2	9.7	13.8	9.2	7.2	4.1	20.0	8.9
	6	0.0	4.1	5.6	4.1	5.6	3.1	3.1	7.7	5.1	8.2	4.1	16.4	13.3	6.7	7.2	5.6	20.1	9.0
	7	0.0	3.1	5.2	5.2	6.2	6.2	1.5	4.6	5.7	5.7	6.7	17.5	12.9	7.2	5.7	6.7	20.2	9.0
	8	0.0	3.6	2.6	4.7	6.3	3.1	6.3	5.7	4.7	4.7	6.8	15.1	13.0	10.9	5.7	6.8	20.8	9.3
H	9	0.0	2.1	4.7	3.2	7.4	3.7	6.3	7.4	6.8	4.2	6.8	11.1	14.2	7.9	6.8	7.4	20.6	9.2
O	10	0.0	0.5	8.4	5.2	4.2	4.7	3.7	6.8	4.7	6.8	4.7	14.7	14.1	5.2	8.9	7.3	20.7	9.3
	11	0.0	2.6	4.2	4.7	5.2	7.9	3.7	2.6	2.6	5.8	7.9	12.6	13.1	14.7	4.2	8.4	21.6	9.6
U	12	0.0	2.6	5.7	7.7	5.2	2.6	2.1	4.1	4.1	2.1	5.7	16.0	12.4	9.8	12.9	7.2	22.3	10.0
	13	0.0	1.0	3.7	6.8	6.8	3.7	3.1	5.8	6.3	3.1	4.2	12.0	12.6	15.2	7.9	7.9	22.1	9.9
	14	0.0	1.6	3.6	7.8	6.8	4.2	6.3	3.1	1.0	4.7	4.2	16.1	15.1	9.4	10.9	5.2	21.4	9.6
R	15	0.0	4.1	5.7	6.7	6.7	3.1	4.6	4.1	5.2	2.1	5.2	14.9	12.4	12.9	8.8	3.6	20.2	9.0
	16	0.0	3.6	8.6	6.1	5.6	4.1	5.1	5.1	6.6	6.6	2.0	12.7	13.7	9.1	7.1	4.1	19.1	8.5
	17	0.0	5.6	6.6	8.6	4.5	8.6	3.5	4.0	3.5	5.6	4.5	16.7	12.1	7.1	4.0	5.1	18.1	8.1
	18	0.5	3.6	10.7	7.6	5.1	4.6	5.1	4.1	3.0	9.6	6.6	12.7	10.2	9.6	3.6	3.6	17.6	7.9
	19	0.5	5.1	9.1	6.6	8.1	5.6	4.1	6.1	3.0	6.1	7.1	10.7	11.2	6.1	5.6	5.1	17.6	7.9
	20	0.0	8.2	6.1	7.7	5.6	6.6	7.7	4.6	5.1	4.6	4.6	10.2	9.2	9.2	5.6	5.1	17.5	7.8
	21	0.0	3.0	7.6	6.6	4.6	5.1	8.6	8.1	3.0	6.6	6.6	12.2	10.2	9.1	4.1	4.6	18.3	8.2
	22	0.0	5.0	6.0	2.5	5.5	7.5	6.5	5.5	4.5	6.5	8.0	14.6	10.1	6.0	6.5	5.0	19.0	8.5
	23	0.0	4.0	4.5	4.0	8.5	4.0	5.5	5.5	6.0	5.5	9.5	12.0	12.5	7.0	5.5	6.0	19.4	8.7
	24	0.0	4.1	5.1	5.6	5.1	6.6	3.6	3.6	8.1	4.6	9.6	15.2	9.6	10.2	5.1	4.1	19.0	8.5
ALL HOURS		0.0	3.9	5.9	5.6	5.5	4.8	4.9	5.2	4.9	5.5	6.0	14.3	12.5	9.0	6.4	5.5	19.8	8.8

SOURCE: GEORESEARCH, INC.

Table IV - 54

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA WEATHER HILL (SPRING)

12/04/76 - 05/31/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
								WIND SPEED (M/SEC)										
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.6	4.1	5.2	11.6	9.9	11.0	7.0	8.7	5.2	7.0	4.7	15.1	5.2	2.9	0.6	1.2	13.8	6.2
	2	0.6	4.7	9.9	11.1	9.4	5.8	6.4	2.9	7.0	10.5	4.7	15.8	5.3	3.5	1.8	0.6	13.9	6.2
	3	0.0	5.3	7.6	11.1	5.3	7.6	3.5	8.2	9.4	7.0	8.2	10.5	10.5	3.5	1.2	1.2	14.8	6.6
	4	0.6	4.6	8.0	8.0	6.9	8.0	7.5	4.6	9.2	4.0	11.5	12.1	7.5	4.6	1.7	1.1	14.9	6.7
	5	0.0	4.0	8.6	8.0	5.1	3.4	4.0	9.7	9.7	7.4	10.9	13.1	8.6	5.7	0.6	1.1	15.7	7.0
	6	0.6	6.9	8.0	4.0	6.9	4.6	9.7	5.1	7.4	7.4	8.6	15.4	9.1	2.9	2.9	0.6	15.3	6.9
	7	0.0	5.8	9.2	8.7	6.9	4.6	6.4	8.1	6.4	8.1	4.0	15.0	11.0	2.3	2.9	0.6	14.9	6.6
	8	0.6	8.7	9.3	6.4	9.9	5.2	3.5	2.9	8.7	4.7	6.4	18.6	8.7	4.7	0.0	1.7	14.7	6.6
H	9	0.0	4.1	2.3	14.6	8.2	7.0	4.1	9.4	4.7	3.5	3.5	15.8	14.0	3.5	2.9	2.3	16.2	7.2
	10	0.0	2.3	6.4	6.9	7.5	5.8	5.8	7.5	5.8	6.9	6.9	12.7	13.3	6.9	3.5	1.7	17.3	7.7
O	11	0.0	1.7	3.4	5.7	9.7	4.0	7.4	5.1	5.1	5.1	7.4	17.1	13.1	10.3	3.4	1.1	18.4	8.2
	12	0.0	1.1	2.8	2.8	8.0	7.4	5.7	5.1	6.8	7.4	9.7	14.8	19.9	2.8	2.3	3.4	18.9	8.4
U	13	0.0	0.0	2.8	3.4	7.3	7.3	7.9	5.6	5.1	6.2	6.2	19.2	16.4	6.2	4.5	1.7	19.3	8.6
	14	0.0	0.6	1.1	4.6	6.3	9.1	5.7	5.1	8.6	4.6	8.6	15.4	17.1	9.1	2.3	1.7	19.2	8.6
R	15	0.0	0.6	1.7	2.8	5.0	5.0	7.8	6.7	5.6	5.0	8.9	22.3	16.2	6.7	4.5	1.1	19.9	8.9
	16	0.0	0.6	0.6	1.7	6.7	3.9	10.0	5.6	8.9	7.2	7.2	21.1	11.1	10.0	5.0	0.6	19.8	8.8
	17	0.0	0.0	1.7	2.8	3.9	10.0	4.4	3.9	8.3	10.6	7.8	16.1	15.6	10.6	2.2	2.2	19.9	8.9
	18	0.0	0.0	2.2	2.2	2.8	5.6	7.8	11.7	10.1	6.7	7.3	17.9	11.7	7.8	4.5	1.7	19.4	8.7
	19	0.0	0.0	0.6	4.5	5.0	6.7	11.2	5.6	8.4	10.6	7.3	15.6	12.8	5.6	4.5	1.7	18.9	8.5
	20	0.0	0.6	3.9	3.9	7.3	7.9	5.6	10.7	7.3	9.0	7.3	13.5	12.4	5.6	2.8	2.2	17.9	8.0
	21	0.0	1.1	5.6	7.8	7.8	5.6	8.9	14.0	7.8	7.3	3.9	15.6	7.8	2.2	3.4	1.1	15.7	7.0
	22	0.0	3.9	7.3	8.9	5.0	8.9	10.1	7.3	8.9	7.8	8.4	10.6	7.3	2.8	2.2	0.6	14.5	6.5
	23	0.0	3.9	7.8	6.7	13.9	7.8	5.0	9.4	8.9	7.8	5.0	13.3	5.6	2.8	2.2	0.0	13.8	6.2
	24	0.0	3.9	5.6	9.4	11.7	6.1	7.8	9.4	10.6	6.1	8.9	8.3	6.1	3.3	2.8	0.0	14.0	6.3
ALL HOURS		0.1	2.8	5.0	6.5	7.3	6.6	6.8	7.2	7.7	7.0	7.2	15.2	11.1	5.3	2.7	1.3	16.7	7.5

SOURCE: GEORESEARCH, INC.

Table IV - 55

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA WEATHER HILL (SUMMER)

12/04/76 - 05/31/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (M/SEC)																AV SPEED	AV SPEED
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	(MPH)	(M/SEC)
	1	0.0	6.9	17.2	16.1	11.5	8.0	5.7	8.0	4.6	5.7	3.4	8.0	1.1	2.3	0.0	1.1	10.4	4.6
	2	0.0	13.8	9.2	20.7	9.2	2.3	9.2	4.6	5.7	6.9	3.4	6.9	4.6	1.1	1.1	1.1	10.6	4.8
	3	0.0	12.6	19.5	10.3	10.3	3.4	3.4	8.0	8.0	4.6	5.7	8.0	1.1	3.4	1.1	0.0	10.6	4.7
	4	0.0	14.9	11.5	10.3	8.0	6.9	11.5	5.7	3.4	10.3	1.1	9.2	4.6	2.3	0.0	0.0	10.7	4.8
	5	0.0	11.8	12.9	9.4	9.4	3.5	3.5	14.1	7.1	8.2	4.7	8.2	5.9	1.2	0.0	0.0	11.2	5.0
	6	0.0	10.6	9.4	14.1	8.2	4.7	4.7	9.4	5.9	9.4	12.9	3.5	4.7	2.4	0.0	0.0	11.5	5.1
	7	0.0	11.6	12.8	11.6	11.6	9.3	3.5	4.7	8.1	9.3	7.0	5.8	3.5	1.2	0.0	0.0	10.4	4.6
	8	0.0	11.4	21.6	11.4	9.1	4.5	6.8	5.7	5.7	6.8	6.8	4.5	4.5	1.1	0.0	0.0	9.7	4.3
H	9	0.0	8.0	14.8	14.8	13.6	6.8	4.5	5.7	9.1	9.1	2.3	6.8	2.3	2.3	0.0	0.0	10.2	4.5
	10	0.0	1.2	11.6	23.3	12.8	9.3	9.3	3.5	4.7	7.0	4.7	8.1	1.2	3.5	0.0	0.0	10.7	4.8
O	11	0.0	0.0	4.6	21.8	20.7	9.2	10.3	6.9	5.7	3.4	2.3	4.6	8.0	1.1	1.1	0.0	11.4	5.1
	12	0.0	0.0	1.1	11.2	20.2	12.4	14.6	10.1	5.6	2.2	2.2	10.1	3.4	5.6	1.1	0.0	13.0	5.8
U	13	0.0	0.0	2.3	5.7	18.2	11.4	5.7	12.5	15.9	3.4	1.1	9.1	6.8	5.7	2.3	0.0	14.7	6.6
	14	0.0	0.0	1.2	1.2	5.9	17.6	12.9	5.9	12.9	11.8	3.5	5.9	11.8	7.1	2.4	0.0	16.6	7.4
R	15	0.0	0.0	2.4	2.4	9.4	10.6	12.9	8.2	2.4	5.9	8.2	12.9	10.6	10.6	1.2	2.4	17.8	8.0
	16	0.0	0.0	0.0	6.0	9.6	10.8	13.3	7.2	8.4	3.6	6.0	16.9	9.6	4.8	1.2	2.4	16.8	7.5
	17	0.0	0.0	1.2	4.9	3.7	2.4	14.6	11.0	11.0	7.3	9.8	18.3	9.8	6.1	0.0	0.0	17.2	7.7
	18	0.0	1.2	2.4	3.5	8.2	3.5	10.6	15.3	5.9	4.7	7.1	25.9	4.7	5.9	1.2	0.0	16.8	7.5
	19	0.0	0.0	2.3	4.6	8.0	13.8	9.2	10.3	2.3	4.6	12.6	16.1	9.2	3.4	2.3	1.1	16.6	7.4
	20	0.0	1.2	2.4	4.7	12.9	8.2	12.9	3.5	7.1	10.6	7.1	12.9	7.1	7.1	1.2	1.2	16.1	7.2
	21	0.0	1.2	4.7	7.1	15.3	14.1	7.1	3.5	7.1	8.2	7.1	7.1	10.6	2.4	2.4	2.4	15.0	6.7
	22	0.0	3.4	8.0	12.6	8.0	4.6	14.9	12.6	6.9	10.3	1.1	5.7	6.9	2.3	1.1	1.1	12.9	5.8
	23	0.0	5.7	11.4	9.1	14.8	10.2	5.7	9.1	2.3	10.2	6.8	6.8	3.4	1.1	1.1	2.3	12.2	5.5
	24	0.0	8.0	11.5	12.6	18.4	8.0	4.6	3.4	6.9	5.7	6.9	8.0	2.3	1.1	1.1	1.1	11.0	4.9
ALL HOURS		0.0	5.2	8.2	10.4	11.6	8.2	8.8	7.9	6.8	7.1	5.6	9.5	5.7	3.5	0.9	0.7	13.1	5.8

SOURCE: GEORESEARCH, INC.

Table IV - 56

Percentage Frequency Summary for Wind Speed

DEER LODGE COUNTY - ANACONDA WEATHER HILL (AUTUMN)

12/04/76 - 05/31/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)																
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.8	9.0	6.6	4.9	13.9	9.0	4.1	4.1	9.0	8.2	3.3	13.9	7.4	2.5	3.3	0.0	13.8	6.2
	2	1.6	6.6	6.6	7.4	9.8	4.9	7.4	7.4	8.2	6.6	5.7	10.7	10.7	1.6	4.1	0.8	14.8	6.6
	3	0.8	6.6	4.9	6.6	9.0	9.0	2.5	9.0	7.4	10.7	4.1	14.8	6.6	4.9	2.5	0.8	15.0	6.7
	4	0.0	4.2	8.3	9.2	3.3	6.7	5.8	5.8	8.3	8.3	9.2	14.2	10.8	3.3	1.7	0.8	15.6	7.0
	5	0.0	4.2	7.6	6.7	7.6	2.5	3.4	7.6	9.2	9.2	8.4	15.1	10.9	5.0	0.8	1.7	16.4	7.3
	6	1.7	2.5	5.9	7.6	4.2	5.9	5.0	7.6	8.4	6.7	8.4	16.8	10.9	3.4	3.4	1.7	16.7	7.5
	7	0.8	5.9	4.2	5.9	4.2	6.8	6.8	7.6	7.6	2.5	11.9	13.6	15.3	0.8	5.1	0.8	16.7	7.5
	8	0.8	7.4	4.1	4.9	3.3	5.7	6.6	8.2	4.1	5.7	8.2	18.9	9.8	5.7	5.7	0.8	17.4	7.8
H	9	0.8	4.2	9.2	6.7	5.0	4.2	3.4	7.6	8.4	2.5	8.4	12.6	15.1	6.7	4.2	0.8	17.1	7.7
	10	0.0	6.7	6.7	5.0	5.8	6.7	5.0	4.2	6.7	5.8	3.3	13.3	16.7	9.2	2.5	2.5	18.0	8.1
O	11	0.8	2.5	7.4	8.2	4.9	5.7	9.8	2.5	4.9	2.5	2.5	14.8	17.2	9.8	6.6	0.0	18.2	8.2
	12	0.0	1.6	4.1	8.9	10.6	8.9	2.4	4.9	5.7	3.3	4.1	12.2	18.7	10.6	4.1	0.0	18.0	8.1
U	13	0.0	0.0	5.0	4.1	9.1	10.7	5.8	5.0	3.3	8.3	2.5	18.2	9.9	12.4	4.1	1.7	18.6	8.3
	14	0.0	0.0	2.5	4.2	9.2	10.8	5.8	5.0	6.7	5.8	6.7	10.8	17.5	10.8	4.2	0.0	18.7	8.4
R	15	0.0	0.8	4.1	4.9	5.7	4.9	9.0	7.4	11.5	2.5	4.1	17.2	16.4	8.2	2.5	0.8	18.3	8.2
	16	0.0	3.3	3.3	3.3	5.7	6.6	8.2	7.4	9.0	7.4	6.6	20.5	13.1	4.1	0.8	0.8	17.2	7.7
	17	0.0	2.5	3.3	5.7	8.2	5.7	5.7	13.9	5.7	7.4	10.7	9.0	13.1	5.7	2.5	0.8	16.9	7.5
	18	0.0	2.5	5.7	4.9	4.9	10.7	13.1	9.8	10.7	3.3	4.9	14.8	8.2	4.9	0.0	1.6	15.5	6.9
	19	0.0	3.3	5.7	6.5	8.9	14.6	13.0	11.4	5.7	5.7	3.3	10.6	8.1	1.6	0.0	1.6	13.7	6.1
	20	0.0	5.7	13.0	8.9	5.7	8.9	6.5	10.6	8.9	8.1	4.9	4.9	8.9	3.3	0.8	0.8	13.1	5.8
	21	0.8	7.3	10.5	10.5	8.1	6.5	9.7	6.5	6.5	7.3	6.5	6.5	6.5	5.6	0.0	1.6	13.2	5.9
	22	0.0	7.2	9.6	15.2	7.2	4.8	8.0	11.2	6.4	4.0	3.2	10.4	4.8	5.6	0.8	1.6	13.3	5.9
	23	0.0	8.0	10.4	11.2	12.0	5.6	7.2	4.8	5.6	7.2	2.4	11.2	7.2	4.0	1.6	1.6	13.4	6.0
	24	0.0	8.8	8.8	9.6	6.4	4.8	4.8	14.4	7.2	6.4	4.0	11.2	6.4	5.6	0.0	1.6	13.7	6.1
ALL HOURS		0.4	4.6	6.6	7.2	7.2	7.1	6.6	7.7	7.3	6.1	5.7	13.1	11.2	5.6	2.5	1.1	16.0	7.1

SOURCE: GEORESEARCH, INC.

Table IV - 57

Annual Wind Rose Distribution

DEER LODGE COUNTY - ANACONDA WEATHER HILL

12/04/76 - 05/31/79

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	1.7	0.1- 0.4
1.1- 2.0	0.0	0.1	0.1	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.3	0.3	0.1	0.1	0.1	0.1	2.5	0.5- 0.9
2.1- 3.0	0.1	0.1	0.3	0.3	0.3	0.2	0.2	0.1	0.2	0.2	0.3	0.2	0.1	0.1	0.1	0.1	2.8	1.0- 1.3 S
3.1- 4.0	0.1	0.1	0.3	0.5	0.3	0.3	0.2	0.2	0.2	0.1	0.4	0.4	0.1	0.2	0.1	0.0	3.4	1.4- 1.8 P
S 4.1- 5.0	0.0	0.1	0.3	0.6	0.4	0.3	0.1	0.1	0.2	0.2	0.3	0.4	0.2	0.1	0.1	0.1	3.5	1.9- 2.2 E
P 5.1- 6.0	0.1	0.1	0.2	0.6	0.4	0.3	0.2	0.1	0.1	0.2	0.3	0.5	0.2	0.1	0.1	0.0	3.4	2.3- 2.7 E
E 6.1- 7.0	0.0	0.1	0.3	0.8	0.3	0.2	0.2	0.2	0.1	0.2	0.4	0.5	0.3	0.2	0.1	0.0	3.8	2.8- 3.1 D
E 7.1- 8.0	0.0	0.0	0.2	0.6	0.4	0.2	0.1	0.0	0.1	0.1	0.3	0.6	0.3	0.2	0.1	0.0	3.4	3.2- 3.6
D 8.1- 9.0	0.0	0.0	0.4	0.7	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.6	0.2	0.2	0.1	0.0	3.2	3.7- 4.0 M
9.1-10.0	0.0	0.1	0.3	0.5	0.1	0.2	0.1	0.1	0.0	0.1	0.2	0.8	0.4	0.2	0.1	0.1	3.2	4.1- 4.5 E
M 10.1-11.0	0.0	0.0	0.3	0.6	0.1	0.2	0.1	0.0	0.1	0.1	0.2	1.0	0.4	0.2	0.0	0.0	3.4	4.6- 4.9 T
I 11.1-12.0	0.0	0.0	0.4	0.4	0.1	0.2	0.1	0.0	0.1	0.1	0.3	0.9	0.3	0.2	0.0	0.0	3.1	5.0- 5.4 E
L 12.1-13.0	0.0	0.0	0.3	0.4	0.0	0.1	0.1	0.0	0.0	0.1	0.3	1.2	0.4	0.2	0.1	0.0	3.2	5.5- 5.8 R
E 13.1-14.0	0.0	0.0	0.3	0.3	0.0	0.1	0.1	0.0	0.0	0.1	0.3	1.4	0.5	0.4	0.1	0.0	3.6	5.9- 6.3 S
S 14.1-15.0	0.0	0.0	0.2	0.3	0.0	0.1	0.1	0.0	0.0	0.1	0.2	1.4	0.4	0.3	0.1	0.0	3.1	6.4- 6.7 /
/ 15.1-16.0	0.0	0.0	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.3	1.6	0.4	0.3	0.1	0.0	3.4	6.8- 7.2 S
H 16.1-17.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	1.6	0.4	0.4	0.1	0.0	3.2	7.3- 7.6 E
O 17.1-18.0	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.2	1.7	0.5	0.3	0.1	0.0	3.1	7.7- 8.0 C
U 18.1-19.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.6	0.5	0.3	0.1	0.0	3.1	8.1- 8.5 O
R 19.1-20.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.8	0.4	0.4	0.0	0.0	3.2	8.6- 8.9 N
20.1-25.0	0.0	0.0	0.7	0.2	0.0	0.0	0.1	0.0	0.0	0.1	0.7	7.5	1.8	2.0	0.1	0.0	13.3	9.0-11.2 D
25.1-30.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7	6.0	1.7	1.8	0.0	0.0	10.8	11.3-13.4
30.1-35.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	3.7	0.9	1.1	0.0	0.0	6.3	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.6	0.4	0.5	0.0	0.0	3.7	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.8	0.5	0.3	0.0	0.0	2.6	>17.9
CALM																	0.1	CALM
TOTAL	0.6	0.9	6.3	8.1	3.1	3.0	2.0	1.4	1.4	2.2	7.3	40.0	11.5	10.1	1.5	0.6	100.0	TOTAL
AV SPD (MPH)	7.2	7.9	13.4	9.1	5.9	7.1	7.6	6.5	6.5	7.9	14.5	21.9	19.9	21.5	10.4	6.4	17.0	AV SPD (MPH)
AV SPD (M/S)	3.2	3.6	6.0	4.0	2.7	3.2	3.4	2.9	2.9	3.5	6.5	9.8	8.9	9.6	4.7	2.9	7.6	AV SPD (M/S)

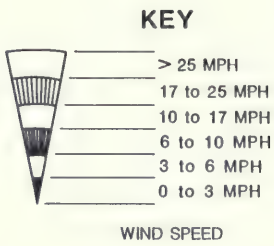
SOURCE: GEORESEARCH, INC.

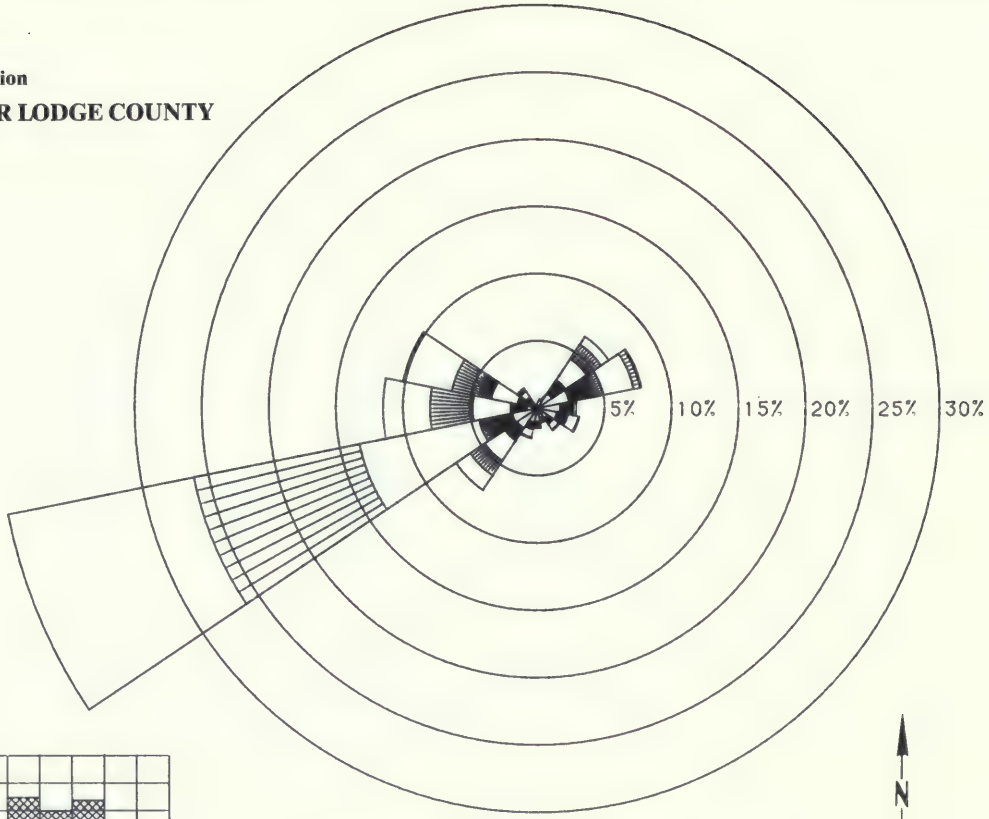
Figure IV - 6

Annual Wind Rose Distribution

ANACONDA WEATHER HILL — DEER LODGE COUNTY

(1976 - 1979)





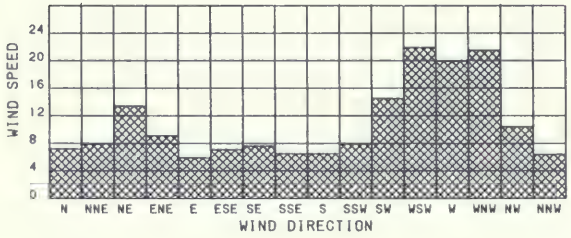


Table IV - 58

Coefficients of Weibull Distribution

DEER LODGE COUNTY - ANACONDA WEATHER HILL

12/04/76 - 05/31/79

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	9.6346	1.2677
FEBRUARY	9.4117	1.2555
MARCH	10.6592	1.3294
APRIL	8.1883	1.5939
MAY	9.0770	1.7469
JUNE	7.0264	1.7153
JULY	5.5180	1.4126
AUGUST	6.9648	1.3803
SEPTEMBER	8.5019	1.6952
OCTOBER	8.7946	1.4047
NOVEMBER	7.6801	1.0634
DECEMBER	11.6991	1.1168
YEAR	9.2157	1.4134

SOURCE: GEORESEARCH, INC.

LEWISTOWN FAA AIRPORT

FERGUS COUNTY

The Lewistown airport is located approximately 4 miles southwest of Lewistown at 47 03 00 N and 109 27 00 W (Site No. 40 on Map II-1). Elevation at the airport is 4,143 feet. Meteorological data have been collected at the airport for many years by the Federal Aviation Administration.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in reporting interval, the data set was split into two parts for analysis: December 21, 1949, through August 15, 1962; and October 13, 1964, through December 31, 1978. Data from the latter period only were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Lewistown consists of summaries of observations made every third hour from October 13, 1964, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 6.1 meters. The site is representative of a limited area within a few miles of Lewistown, since the area is surrounded by mountains.

Average annual wind speed at the airport was 10.1 miles per hour. Average monthly wind speeds ranged from 8.3 miles per hour in July to 11.2 miles per hour in December and January.

Average annual wind power was 109.0 watts/m^2. Average monthly wind power ranged from 54.0 watts/m^2 in July to 164.0 watts/m^2 in January.

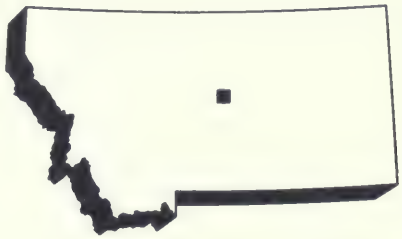


Table IV - 59

Monthly Wind Speed Distribution

FERGUS COUNTY - LEWISTOWN FAA AIRPORT

10/13/64 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	9.5	9.8	8.0	7.7	9.5	9.2	10.6	10.1	9.4	8.3	9.8	9.3	9.3	CALM (<0.5)
1.1- 3.1	0.5	0.4	0.4	0.2	0.2	0.5	0.7	0.2	0.4	0.5	0.4	0.5	0.4	0.5- 1.4
3.4- 5.4	7.2	7.4	6.4	5.9	7.0	8.3	9.6	9.5	8.2	7.8	7.9	6.6	7.7	1.5- 2.4 S
S 5.6- 7.6	16.5	18.8	18.2	17.4	18.8	22.3	27.1	26.1	25.7	23.2	19.2	17.0	20.8	2.5- 3.4 P
P 7.8- 9.8	14.0	13.3	14.5	16.0	16.6	19.8	19.7	19.9	18.8	15.5	15.2	14.1	16.5	3.5- 4.4 E
E 10.1-12.1	13.5	11.7	14.6	16.0	14.9	14.6	14.4	14.2	13.7	14.2	13.5	13.5	14.1	4.5- 5.4 E
E 12.3-14.3	8.6	9.9	11.3	10.8	10.2	8.5	7.9	7.7	7.7	9.2	9.6	9.5	9.2	5.5- 6.4 D
D 14.5-16.6	6.5	7.5	7.1	7.4	6.4	5.9	3.9	4.3	4.8	5.8	6.3	7.8	6.1	6.5- 7.4
16.8-18.8	9.5	9.6	9.8	9.9	8.6	6.8	4.1	4.5	6.9	7.8	9.2	9.2	8.0	7.5- 8.4 M
M 19.0-21.0	4.8	4.6	4.9	4.1	4.0	2.3	1.4	2.0	2.4	3.6	3.9	4.9	3.6	8.5- 9.4 E
I 21.3-23.3	5.3	4.0	3.1	3.0	2.7	1.4	0.5	1.1	1.2	2.4	3.2	4.3	2.7	9.5-10.4 T
L 23.5-25.5	1.3	1.2	0.6	0.7	0.5	0.3	0.0	0.1	0.5	0.8	0.5	1.3	0.7	10.5-11.4 E
E 25.7-27.7	0.7	0.7	0.3	0.2	0.3	0.1	0.0	0.0	0.1	0.2	0.4	0.6	0.3	11.5-12.4 R
S 28.0-30.0	1.3	0.7	0.6	0.4	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.9	0.4	12.5-13.4 S
/ 30.2-32.2	0.3	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.1	13.5-14.4 /
H 32.4-34.4	0.2	0.1	0.1	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	14.5-15.4 S
O 34.7-36.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4 E
U 36.9-38.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	11.2	10.7	11.0	11.0	10.3	9.4	8.3	8.7	9.2	10.1	10.3	11.2	10.1	
AVERAGE SPEED (M/SEC)	5.0	4.8	4.9	4.9	4.6	4.2	3.7	3.9	4.1	4.5	4.6	5.0	4.5	
AVERAGE WIND POWER (WATTS/M**2)	164.0	143.0	129.0	124.0	104.0	78.0	54.0	64.0	78.0	104.0	119.0	148.0	109.0	

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

BIG PRAIRIE
FLATHEAD COUNTY

The Big Prairie air monitoring site was established by the Montana Air Quality Bureau as part of the Flathead River Basin Environmental Impact Study. The site is located near Polebridge at 48 48 29 N and 114 18 41 W (Site No. 41 on Map II-1 in the valley of the North Fork of the Flathead River. Elevation at the site is 3,587 feet. The valley in this area is about 5 miles wide and is bordered by mountain ranges rising 8,000 and 10,000 feet above sea level. The valley site, therefore, is representative only of a relatively small area.

Data collection began on November 7, 1978, and data through January 4, 1982, were available for analysis. Data recovery, however, was poor, ranging from 0.0 percent in February to 93.0 percent in July. Overall data recovery during the monitoring period was 42.8 percent. The site is located 2 miles from the nearest road, and because of heavy snow and severe cold, it frequently is inaccessible during the winter. Consequently, major breaks exist in the data set. No data are available for the periods December 25, 1978, through June 7, 1979, and November 8, 1979, through March 31, 1980. Winds were monitored long enough, however, to adequately represent the wind resource at this location during the summer months.

The data set contains hourly averages of wind speed and wind direction manually reduced from stripchart records. The data were collected by a battery-operated Climatronics electronic anemometer and wind vane on a 10-meter tower.

Average monthly wind speeds were low at this site; they ranged from 2.4 miles per hour in January to 4.8 miles per hour in April. Average annual wind speed was 3.4 miles per hour. Average wind speeds were highest from April through July.

Average annual wind power at the site was 8.4 watts/m^2. Monthly averages varied from 4.2 watts/m^2 in January to 18.0 watts/m^2 in April.

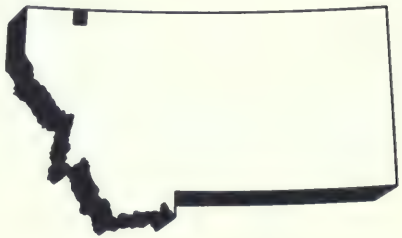


Table IV - 60

Monthly Wind Speed Distribution

FLATHEAD COUNTY - BIG PRAIRIE

11/07/78 - 01/04/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	8.1	0.0	7.7	13.8	15.3	13.4	13.5	20.6	29.0	30.2	15.2	7.5	17.0	CALM
0.1-1.0	12.8	0.0	5.1	3.2	1.6	1.2	2.6	3.8	2.7	5.4	4.4	15.8	4.2	0.1- 0.4
1.1-2.0	37.2	0.0	23.8	11.6	12.0	12.7	13.8	13.3	12.4	17.0	20.4	31.4	16.2	0.5- 0.9
2.1-3.0	12.8	0.0	12.6	11.4	15.6	14.5	13.6	15.0	13.9	14.6	22.8	15.3	15.4	1.0- 1.3
3.1-4.0	7.0	0.0	9.8	8.6	9.8	12.1	9.6	10.5	8.2	5.7	10.9	8.1	9.6	1.4- 1.8
4.1-5.0	5.8	0.0	9.1	5.0	10.1	8.7	7.9	9.0	6.8	5.0	6.1	6.0	7.5	1.9- 2.2
5.1-6.0	1.2	0.0	7.7	5.1	7.0	6.9	8.8	7.8	5.8	6.0	5.6	3.7	6.6	2.3- 2.7
6.1-7.0	5.8	0.0	5.1	6.0	6.2	5.9	6.6	6.0	6.1	4.8	6.0	3.3	5.8	2.8- 3.1
7.1-8.0	3.5	0.0	7.9	9.0	7.0	7.8	7.6	4.9	5.2	5.4	3.7	4.0	6.0	3.2- 3.6
8.1-9.0	3.5	0.0	5.1	7.6	4.2	6.4	7.2	4.2	4.4	2.2	1.7	2.1	4.6	3.7- 4.0
9.1-10.0	1.2	0.0	2.8	5.3	3.3	3.5	3.7	2.4	2.2	1.5	1.3	0.7	2.6	4.1- 4.5
10.1-11.0	1.2	0.0	0.9	5.5	3.1	3.5	2.9	1.3	1.3	0.6	0.6	1.0	2.0	4.6- 4.9
11.1-12.0	0.0	0.0	0.7	3.5	1.5	1.9	1.2	0.6	0.9	1.2	0.6	0.5	1.1	5.0- 5.4
12.1-13.0	0.0	0.0	1.6	2.7	1.9	1.1	0.5	0.4	0.4	0.4	0.1	0.0	0.7	5.5- 5.8
13.1-14.0	0.0	0.0	0.0	1.0	0.8	0.4	0.3	0.2	0.3	0.0	0.3	0.3	0.4	5.9- 6.3
14.1-15.0	0.0	0.0	0.0	0.5	0.7	0.0	0.1	0.1	0.1	0.0	0.1	0.3	0.2	6.4- 6.7
15.1-16.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	6.8- 7.2
16.1-17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	7.3- 7.6
17.1-18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7- 8.0
18.1-19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1- 8.5
19.1-20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6- 8.9
20.1-25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9,0-11.2
25.1-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	2.4	ND	3.7	4.8	4.1	4.1	4.0	3.2	3.0	2.5	2.8	2.5	3.4	
AVERAGE SPEED (M/SEC)	1.1	ND	1.6	2.2	1.8	1.8	1.8	1.4	1.3	1.1	1.2	1.1	1.5	
AVERAGE WIND POWER (WATTS/M**2)	4.2	ND	8.8	18.0	12.0	10.9	9.6	6.4	7.1	5.2	5.0	4.7	8.4	
PERCENT DATA RECOVERY	3.7	0.0	19.2	27.9	38.5	65.5	93.0	75.4	67.5	30.6	57.8	32.8	42.8	

SPEED / MONTH

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 11850
PERCENTAGE DATA RECOVERY = 42.8

SOURCE: GEORESEARCH, INC.

COLUMBIA FALLS WATER SUPPLY

FLATHEAD COUNTY

The Columbia Falls Water Supply air monitoring site is located about 1 mile northeast of Columbia Falls at 48 24 05 N and 114 08 32 W (Site No. 46 on Map II-1). Elevation at the site is 3,129 feet. The site was established by the Montana Air Quality Bureau to measure particulate concentrations in the area and to provide data for the Flathead River Basin Environmental Impact Study.

Wind data collected from February 16, 1977, through October 22, 1979, were available for analysis. The data set contains hourly averages for wind speed and direction manually reduced from stripchart records. The data were gathered by a Climatronics electronic anemometer and wind vane on a 10-meter tower.

Winds have been monitored long enough to adequately represent the wind resource at this location. The site is representative only of the immediate area, however, because it is located at the base of Teakettle Mountain and near the mouth of a large canyon. Data recovery, which for the period was 83.7 percent, ranged from 66.9 percent in August to 96.9 percent in October.

Average monthly wind speeds varied from 5.0 miles per hour in September to 7.7 miles per hour in August. Average annual wind speed was 6.4 miles per hour.

Average monthly wind power ranged from 15.9 watts/m^2 in September to 100.6 watts/m^2 in February. Average annual wind power was 48.3 watts/m^2.

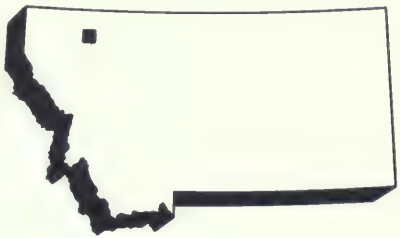


Table IV - 61

Monthly Wind Speed Distribution

FLATHEAD COUNTY - COLUMBIA FALLS WATER SUPPLY

02/16/77 - 10/22/79

MILES/HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	0.0	0.2	0.1	0.7	0.5	1.3	0.2	0.3	0.1	0.1	0.0	0.0	0.3
0.1-1.0	2.0	0.5	0.2	0.0	0.0	1.2	0.1	0.4	0.7	0.2	0.5	0.1	0.5
1.1-2.0	9.4	6.3	2.5	1.1	2.7	4.1	3.2	4.4	5.5	3.3	4.2	3.2	4.0
2.1-3.0	17.6	15.8	7.6	5.6	6.6	9.3	8.7	6.2	10.5	9.4	8.5	11.5	9.4
3.1-4.0	20.7	17.8	14.2	10.0	11.2	13.7	18.1	10.3	17.7	19.3	14.3	14.7	15.1
4.1-5.0	11.4	10.6	13.3	11.4	13.6	16.9	14.2	13.7	19.1	19.6	13.8	11.3	14.4
5.1-6.0	8.3	9.9	13.5	14.1	13.4	15.1	13.2	12.9	15.7	17.7	11.8	13.0	13.5
6.1-7.0	4.4	6.7	8.4	10.7	10.8	9.3	11.9	8.2	9.9	8.8	8.0	6.5	8.9
7.1-8.0	4.6	5.2	6.7	10.1	10.9	8.6	9.9	8.7	8.5	6.9	7.6	6.4	8.0
8.1-9.0	3.1	7.0	5.3	8.9	7.1	6.8	5.6	5.5	5.1	4.5	4.9	4.4	5.8
9.1-10.0	1.7	2.6	3.6	5.6	5.6	3.1	2.1	2.9	1.6	2.0	3.1	3.4	3.2
10.1-11.0	2.3	3.9	4.8	4.4	6.0	3.4	3.7	4.1	1.7	2.7	4.9	4.7	3.9
11.1-12.0	1.5	1.1	2.7	3.0	3.2	1.7	1.4	2.0	0.8	1.0	2.9	3.4	2.0
12.1-13.0	1.8	1.2	2.4	3.3	2.9	1.3	1.1	2.1	0.3	1.0	2.9	3.7	1.9
13.1-14.0	1.6	0.7	1.8	1.3	2.3	0.7	1.2	2.5	0.3	0.8	2.0	2.0	1.4
14.1-15.0	0.7	0.5	1.3	1.2	0.9	0.4	0.6	1.2	0.7	0.5	0.9	1.5	0.9
15.1-16.0	1.1	0.4	2.4	1.3	1.3	0.8	0.9	2.9	0.5	0.6	2.7	1.5	1.3
16.1-17.0	0.7	0.2	1.4	1.0	0.4	0.6	0.5	0.8	0.2	0.5	1.4	0.5	0.7
17.1-18.0	0.4	0.2	1.1	1.0	0.0	0.4	1.1	1.7	0.3	0.4	1.5	0.2	0.7
18.1-19.0	0.2	0.9	0.5	0.8	0.2	0.6	0.9	2.1	0.1	0.5	0.2	0.8	0.6
19.1-20.0	0.6	0.6	0.5	0.4	0.0	0.1	0.4	0.9	0.2	0.2	0.4	1.1	0.4
20.1-25.0	3.4	4.2	4.1	3.9	0.4	0.8	1.0	5.9	0.8	0.4	1.6	4.7	2.4
25.1-30.0	1.4	2.3	1.4	0.3	0.0	0.0	0.1	0.3	0.0	0.0	0.9	1.4	0.6
30.1-35.0	1.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.2
35.1-40.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
>40.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	6.1	6.8	7.5	7.5	6.4	5.5	5.9	7.7	5.0	5.3	7.1	7.4	6.4
AVERAGE SPEED (M/SEC)	2.7	3.0	3.3	3.3	2.9	2.5	2.6	3.4	2.2	2.3	3.2	3.3	2.9
AVERAGE WIND POWER (WATTS/M**2)	81.1	100.6	72.6	56.6	26.7	21.3	27.1	66.8	15.9	17.8	71.8	73.9	48.3
PERCENT DATA RECOVERY	95.3	78.2	87.5	84.0	96.5	73.6	72.5	66.9	93.9	96.9	88.6	72.2	83.7

SPEED (MPH)
CALM
0.1- 0.4
0.5- 0.9
1.0- 1.3
1.4- 1.8
1.9- 2.2
2.3- 2.7
2.8- 3.1
3.2- 3.6
3.7- 4.0
4.1- 4.5
4.6- 4.9
5.0- 5.4
5.5- 5.8
5.9- 6.3
6.4- 6.7
6.8- 7.2
7.3- 7.6
7.7- 8.0
8.1- 8.5
8.6- 8.9
9,0-11.2
11.3-13.4
13.5-15.6
15.7-17.9
>17.9

SPEED (MPH)

METERS/SECOND

MILES/HOUR

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 19642
PERCENTAGE DATA RECOVERY = 83.7

SOURCE: GEORESEARCH, INC.

KALISPELL NWS AIRPORT

FLATHEAD COUNTY

The Kalispell NWS Airport is located approximately 8 miles north-northeast of Kalispell at 48 18 40 N and 114 16 00 W (Site No. 48 on Map II-1). Elevation at the airport is 2,978 feet.

Meteorological data have been collected at this site for many years by the National Weather Service. These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in anemometer heights and reporting intervals, the data set was broken into four parts for analysis: May 1, 1949, through June 30, 1953; July 1, 1953, through June 30, 1959; July 1, 1959, through June 30, 1964; and July 1, 1964, through December 31, 1978. Only data from the most recent of these periods were selected for inclusion in the *Montana Wind Energy Atlas.*

The data set for the site consists of summaries of observations made every third hour from July 1, 1964, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 6.1 meters. The site is representative only of the immediate area because winds at the site are influenced by Flathead Lake to the south and a canyon to the northeast.

Average monthly wind speeds at Kalispell varied from 5.6 miles per hour in October and November to 8.5 miles per hour in April. Average annual wind speed was 6.9 miles per hour.

Average monthly wind power ranged from 34.0 watts/m^2 in October to 78.0 watts/m^2 in January. Average annual wind power at the site was 53.0 watts/m^2.

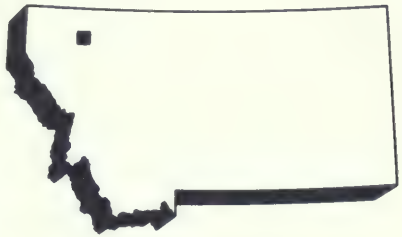


Table IV - 62

Monthly Wind Speed Distribution

FLATHEAD COUNTY - KALISPELL NWS AIRPORT

07/01/64 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM (<1.1)	27.1	24.2	16.3	10.7	10.8	9.4	12.6	13.7	17.8	25.4	29.0	29.4	18.9
1.1- 3.1	1.1	1.1	0.6	0.2	0.5	0.5	1.2	1.6	1.7	0.7	1.3	1.3	1.0
3.4- 5.4	22.1	23.7	20.3	19.7	18.9	21.6	25.3	24.8	24.6	27.6	26.2	23.6	23.3
5.6- 7.6	12.8	14.1	17.8	18.4	20.9	22.4	23.0	21.7	20.5	17.5	15.0	14.9	18.3
7.8- 9.8	10.2	10.6	13.7	15.2	16.7	16.6	14.8	14.7	12.6	10.8	10.1	9.5	12.9
10.1-12.1	8.6	10.4	11.8	12.1	12.7	12.6	11.0	10.7	9.3	7.7	7.2	8.1	10.1
12.3-14.3	6.0	5.6	7.4	8.9	9.1	8.2	6.3	6.5	6.0	4.9	4.6	5.1	6.5
14.5-16.6	4.1	3.9	5.2	6.1	5.6	4.6	3.0	2.9	3.3	2.3	2.6	3.3	3.9
16.8-18.8	2.6	2.8	2.9	3.9	2.3	2.7	1.9	1.6	2.2	1.8	2.0	1.9	2.4
19.0-21.0	2.2	1.5	1.5	2.3	1.4	0.9	0.6	1.2	1.2	0.8	0.8	1.2	1.3
21.3-23.3	1.2	0.7	1.2	1.3	0.7	0.3	0.1	0.4	0.4	0.3	0.5	0.9	0.7
23.5-25.5	0.8	0.5	0.4	0.7	0.2	0.1	0.1	0.1	0.2	0.1	0.4	0.3	0.3
25.7-27.7	0.5	0.3	0.5	0.4	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.2	0.2
28.0-30.0	0.4	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
30.2-32.2	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
32.4-34.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
34.7-36.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	6.7	6.5	7.6	8.5	8.1	7.6	6.7	6.7	6.5	5.6	5.6	5.8	6.9
AVERAGE SPEED (M/SEC)	3.0	2.9	3.4	3.8	3.6	3.4	3.0	3.0	2.9	2.5	2.5	2.6	3.1
AVERAGE WIND POWER (WATTS/M**2)	78.0	61.0	71.0	77.0	57.0	49.0	39.0	40.0	44.0	34.0	41.0	51.0	53.0

SPEED (MPH) / SPEED (M/SEC)

CALM (<0.5)
0.5- 1.4
1.5- 2.4
2.5- 3.4
3.5- 4.4
4.5- 5.4
5.5- 6.4
6.5- 7.4
7.5- 8.4
8.5- 9.4
9.5-10.4
10.5-11.4
11.5-12.4
12.5-13.4
13.5-14.4
14.5-15.4
15.5-16.4
16.5-17.4
17.5-18.4
18.5-19.4
19.5-20.4
20.5-25.4
25.5-30.4
30.5-35.4
35.5-40.4
>40.4

SPEED (MPH) / SPEED (M/SEC) / WIND POWER (WATTS/M**2)

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

BOZEMAN FAA AIRPORT

GALLATIN COUNTY

The Bozeman airport is located about 7 miles northwest of Bozeman at 45 46 48 N and 111 09 00 W (Site No. 51 on Map II-1). Elevation at the airport is 4,468 feet. Meteorological data were collected at this site for several years by the Federal Aviation Administration.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the Battelle data set was split into two parts for analysis: January 1, 1948, through April 27, 1951; and April 28, 1951, through December 31, 1954. Data from the latter period only were chosen for inclusion in the *Montana Wind Energy Atlas.*

The data set for Bozeman consists of summaries derived from hourly observations made from April 28, 1951, through December 31, 1954. The anemometer was mounted on a rooftop at a height of 13.1 meters. The site is representative of the lower Gallatin River valley from Bozeman to Belgrade.

Average annual wind speed was 7.8 miles per hour. Monthly wind speeds ranged from an average of 6.7 miles per hour in November and December to an average of 9.4 miles per hour in April.

Average monthly wind power ranged from 47.0 watts/m² in October to 96.0 watts/m² in April and May. Average annual wind power was 71.0 watts/m².

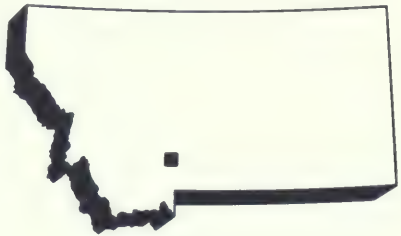


Table IV - 63

Monthly Wind Speed Distribution

GALLATIN COUNTY - BOZEMAN FAA AIRPORT

04/28/51 - 12/31/54

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM (<1.1)	7.8	8.5	7.0	3.3	2.9	4.8	4.1	3.8	4.6	7.5	10.8	10.8	6.3
1.1- 3.1	4.9	4.0	3.5	2.5	3.1	3.9	4.5	4.3	3.7	7.1	8.2	7.3	4.8
3.4- 5.4	28.6	26.9	26.4	23.9	25.1	27.4	29.4	29.9	27.9	31.3	30.7	30.7	28.3
5.6- 7.6	15.0	14.4	16.9	14.0	13.8	15.1	15.2	17.1	16.5	17.4	16.3	16.7	15.8
7.8- 9.8	11.3	13.2	15.0	12.9	14.1	12.7	13.7	14.4	13.7	11.9	11.1	11.3	12.9
10.1-12.1	12.7	14.5	15.9	19.4	19.4	16.9	17.9	16.5	17.4	13.8	10.8	10.9	15.5
12.3-14.3	4.8	4.9	4.5	6.0	5.4	5.6	5.1	4.9	5.6	4.4	3.5	3.2	4.8
14.5-16.6	3.5	3.7	3.6	5.5	5.1	4.8	3.8	3.3	3.5	2.2	2.2	2.6	3.6
16.8-18.8	4.1	3.7	2.7	5.0	4.1	3.8	2.5	2.6	2.7	1.7	2.4	2.7	3.1
19.0-21.0	2.7	2.1	2.1	2.9	2.2	1.7	1.4	1.1	1.3	0.8	1.1	1.5	1.7
21.3-23.3	1.3	1.2	1.1	1.7	1.6	0.9	0.8	0.6	0.9	0.5	1.0	0.7	1.0
23.5-25.5	1.6	1.1	0.8	1.3	1.5	1.2	0.8	0.6	1.1	0.7	0.5	0.5	1.0
25.7-27.7	1.0	0.4	0.3	1.0	0.8	0.6	0.2	0.6	0.6	0.2	0.8	0.5	0.6
28.0-30.0	0.4	0.6	0.2	0.2	0.3	0.2	0.1	0.1	0.3	0.2	0.3	0.2	0.3
30.2-32.2	0.1	0.3	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.1	0.1
32.4-34.4	0.1	0.3	0.0	0.2	0.2	0.1	0.2	0.0	0.1	0.1	0.2	0.2	0.1
34.7-36.7	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36.9-38.9	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
39.1-41.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	8.1	8.3	7.8	9.4	9.2	8.3	7.8	7.8	8.1	6.9	6.7	6.7	7.8
AVERAGE SPEED (M/SEC)	3.6	3.7	3.5	4.2	4.1	3.7	3.5	3.5	3.6	3.1	3.0	3.0	3.5
AVERAGE WIND POWER (WATTS/M**2)	89.0	92.0	67.0	96.0	96.0	74.0	60.0	59.0	72.0	47.0	60.0	61.0	71.0

SPEED (MPH)

CALM (<0.5)
0.5- 1.4
1.5- 2.4
3.5- 4.4
4.5- 5.4
5.5- 6.4
6.5- 7.4
7.5- 8.4
8.5- 9.4
9.5-10.4
10.5-11.4
11.5-12.4
12.5-13.4
13.5-14.4
14.5-15.4
15.5-16.4
16.5-17.4
17.5-18.4
18.5-19.4
19.5-20.4
20.5-25.4
25.5-30.4
30.5-35.4
35.5-40.4
>40.4

ANEMOMETER HEIGHT = 43.0 FEET = 13.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

BLACKFOOT
GLACIER COUNTY

The Blackfoot site is located four miles northeast of Browning at 48 35 20 N and 112 52 35 W (Site No. 53 on Map II-1). Elevation at the site is 4,280 feet. This monitoring site is part of the Wind Regional Energy Assessment Program run by Oregon State University for Bonneville Power Administration.

The site is in a rolling grasslands area near the Rocky Mountain Front. It is less than 20 miles east of Glacier National Park. The site is representative of a large area. Access to the area is reasonable, with an all weather highway running through the middle of the high wind area. Dirt roads criss-cross the area. Winter access is sometimes hampered by drifting snow and severe weather conditions.

The site is located on the Blackfeet Indian Reservation. Electrical service in the area is provided by the Glacier Electric Cooperative. One 115 kV line runs into Browning from Cut Bank. The nearest commercial airport is located in Cut Bank, nearly 30 miles to the east. Air traffic generally is light.

Collection of wind data began in October 1981, when a wind-run anemometer was installed. Summaries of this data are presented in Appendix C. A data logger was installed on July 30, 1984. Data through October 29, 1985 were available for analysis. BPA currently plans to continue monitoring at the site at least through 1989. The anemometer height is 30 feet.

Data recovery was fair to excellent, ranging from 67.8 percent in December to 100.0 percent in April and June. Overall data recovery was 89.4 percent.

Average monthly wind speeds ranged from 11.2 miles per hour in July to 26.1 miles per hour in February. Average annual wind speed was 16.4 miles per hour.

Average monthly wind power ranged from 87.1 watts/m^2 in July up to 1,300.7 watts/m^2 in February.

Average seasonal wind speeds were 13.4 miles per hour in the summer, 17.3 miles per hour in the autumn, 23.9 miles per hour in the winter, and 15.2 miles per hour in the spring. In the winter, the highest wind speed occurred in mid-morning. In the spring and autumn, highest winds happened mid-morning to mid-afternoon. High winds in the summer were somewhat later, in late afternoon. Diurnal range of average wind speeds was greatest in the winter and less so in the summer and autumn. The range was smallest in the spring.

The most common wind directions were southwest to west. With the exception of winds from the east-southeast through the south, winds from other directions were minimal. By direction, average winds speeds ranged from 20.1 miles per hour from the south-southeast and west-southwest to 8.0 miles per hour from the east-northeast.

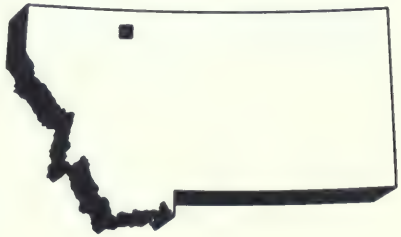


Table IV - 64

Monthly Wind Speed Distribution

GLACIER COUNTY - BLACKFOOT

07/30/84 - 10/29/85

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.9	0.0	1.5	0.1	0.0	0.0	0.0	0.0	0.1	0.5	0.2	0.0	0.2	0.1- 0.4
1.1-2.0	2.2	0.3	1.3	1.0	0.0	0.1	0.0	0.0	0.4	1.4	1.1	0.3	0.6	0.5- 0.9 S
S 2.1-3.0	1.3	0.3	2.1	1.5	0.1	0.3	0.1	0.1	0.9	1.1	2.0	2.1	0.9	1.0- 1.3 P
P 3.1-4.0	2.4	0.8	3.7	1.4	1.1	1.9	1.2	0.3	1.3	2.4	1.9	3.2	1.6	1.4- 1.8 E
E 4.1-5.0	2.4	1.1	5.9	2.2	3.9	4.0	5.0	1.9	2.7	3.7	4.1	1.9	3.2	1.9- 2.2 E
E 5.1-6.0	4.8	0.5	5.0	2.9	5.0	6.9	5.1	3.8	3.3	3.2	2.8	2.9	4.0	2.3- 2.7 D
D 6.1-7.0	1.7	0.8	5.2	3.2	6.5	6.7	8.5	5.5	2.4	4.0	3.1	2.7	4.5	2.8- 3.1
7.1-8.0	3.0	0.5	6.8	3.1	6.6	6.8	8.6	6.0	6.9	4.1	3.0	1.9	5.3	3.2- 3.6 M
M 8.1-9.0	3.7	0.5	5.0	2.6	9.0	9.2	11.1	7.1	6.4	4.2	3.4	1.1	5.9	3.7- 4.0 E
I 9.1-10.0	0.6	0.8	8.5	4.4	10.2	8.5	10.4	6.3	6.8	3.4	2.3	1.3	5.9	4.1- 4.5 T
L 10.1-11.0	1.5	0.8	4.9	3.9	8.3	6.8	7.6	6.1	5.3	3.0	2.3	0.8	4.8	4.6- 4.9 E
E 11.1-12.0	0.9	1.3	4.2	2.6	6.7	6.5	7.7	7.7	4.7	4.6	3.1	3.5	5.1	5.0- 5.4 R
S 12.1-13.0	1.3	2.9	4.1	2.6	6.7	6.4	7.3	6.1	4.9	4.7	3.1	1.1	4.8	5.5- 5.8 S
/ 13.1-14.0	1.7	4.0	3.3	4.0	3.6	4.4	6.0	6.3	4.4	4.0	3.4	2.7	4.4	5.9- 6.3 /
H 14.1-15.0	1.5	4.5	3.4	3.8	3.9	4.6	5.1	6.1	3.4	3.9	5.0	1.9	4.2	6.4- 6.7 S
O 15.1-16.0	1.9	3.7	4.9	4.9	3.5	4.2	4.5	4.9	5.1	3.1	3.9	2.7	4.2	6.8- 7.2 E
U 16.1-17.0	3.2	3.2	3.3	3.2	3.9	3.5	2.2	5.0	3.8	4.0	5.3	1.9	3.8	7.3- 7.6 C
R 17.1-18.0	3.0	3.7	4.2	3.9	3.4	3.1	3.6	4.0	3.1	3.3	4.7	1.9	3.6	7.7- 8.0 O
18.1-19.0	5.0	3.2	2.9	3.1	2.8	1.8	1.9	2.6	3.0	3.5	3.8	1.9	2.9	8.1- 8.5 N
19.1-20.0	1.7	3.2	2.4	2.9	1.9	1.8	1.4	2.4	3.0	3.7	4.1	4.5	2.7	8.6- 8.9 D
20.1-25.0	12.7	15.0	9.6	16.3	7.1	7.6	2.3	8.9	11.1	14.9	13.4	19.0	10.8	9.0-11.2
25.1-30.0	16.6	13.4	5.7	13.6	3.5	3.1	0.1	4.2	8.7	8.7	9.7	13.9	7.4	11.3-13.4
30.1-35.0	9.9	13.1	2.0	7.6	1.7	1.7	0.0	2.9	4.8	6.3	6.3	11.0	4.7	13.5-15.6
35.1-40.0	9.1	8.6	0.2	2.4	0.4	0.1	0.0	1.7	1.3	2.8	4.1	4.8	2.3	15.7-17.9
>40.0	6.9	13.6	0.0	2.8	0.0	0.0	0.0	0.1	2.2	1.2	3.9	11.2	2.3	>17.9
AVERAGE SPEED (MPH)	22.2	26.1	13.2	19.0	13.1	12.8	11.2	14.8	16.5	17.2	18.8	23.5	16.4	
AVERAGE SPEED (M/SEC)	9.9	11.7	5.9	8.5	5.9	5.7	5.0	6.6	7.4	7.7	8.4	10.5	7.3	
AVERAGE WIND POWER (WATTS/M**2)	966.9	1300.7	218.7	575.3	182.4	169.8	87.1	253.9	409.2	449.3	612.6	1127.5	432.3	
PERCENT DATA RECOVERY	74.2	86.6	82.7	100.0	99.9	100.0	99.6	99.9	87.5	76.7	88.9	67.8	89.4	

ANEMOMETER HEIGHT = 9 METERS = 30 FEET
NUMBER OF OBSERVATIONS = 9076
PERCENTAGE DATA RECOVERY = 89.4

SOURCE: GEORESEARCH, INC.

Table IV - 65

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - BLACKFOOT

(WINTER)

07/30/84 - 10/29/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
									WIND SPEED (METERS/SECOND)									AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	0.0	5.0	2.5	5.0	7.5	2.5	0.0	5.0	12.5	2.5	12.5	20.0	10.0	5.0	10.0	23.6	10.5
	2	0.0	5.0	2.5	5.0	2.5	0.0	2.5	5.0	5.0	7.5	7.5	10.0	25.0	15.0	0.0	7.5	22.9	10.2
	3	0.0	2.5	2.5	5.0	2.5	5.0	2.5	7.5	5.0	7.5	2.5	12.5	15.0	25.0	5.0	0.0	22.3	10.0
	4	0.0	2.5	2.5	5.0	2.5	5.0	2.5	7.5	2.5	2.5	10.0	17.5	7.5	20.0	2.5	10.0	22.9	10.2
	5	0.0	0.0	5.0	7.5	0.0	2.5	0.0	7.5	5.0	7.5	5.0	20.0	12.5	20.0	2.5	5.0	23.0	10.3
	6	0.0	0.0	5.0	7.5	2.5	0.0	2.5	10.0	2.5	2.5	10.0	27.5	12.5	7.5	5.0	5.0	22.2	9.9
	7	0.0	0.0	0.0	12.1	0.0	0.0	0.0	6.1	9.1	3.0	0.0	30.3	9.1	18.2	9.1	3.0	24.2	10.8
	8	0.0	0.0	0.0	6.5	0.0	3.2	0.0	0.0	9.7	6.5	6.5	9.7	29.0	12.9	12.9	3.2	25.5	11.4
H	9	0.0	3.2	0.0	0.0	0.0	3.2	3.2	3.2	3.2	6.5	6.5	16.1	19.4	12.9	12.9	9.7	27.2	12.1
	10	0.0	0.0	3.2	0.0	3.2	0.0	3.2	3.2	0.0	3.2	12.9	12.9	19.4	9.7	16.1	12.9	27.7	12.4
O	11	0.0	0.0	3.2	0.0	6.5	0.0	3.2	0.0	0.0	0.0	16.1	16.1	16.1	9.7	12.9	16.1	27.6	12.3
	12	0.0	0.0	0.0	3.2	0.0	6.5	0.0	9.7	0.0	0.0	0.0	25.8	9.7	9.7	16.1	19.4	29.6	13.2
U	13	0.0	2.3	4.7	4.7	2.3	2.3	0.0	4.7	7.0	4.7	2.3	18.6	14.0	9.3	4.7	18.6	25.6	11.4
	14	0.0	2.3	2.3	7.0	0.0	0.0	4.7	4.7	7.0	2.3	9.3	23.3	7.0	9.3	7.0	14.0	24.5	11.0
R	15	0.0	2.9	0.0	0.0	11.8	0.0	0.0	2.9	0.0	17.6	5.9	11.8	8.8	17.6	11.8	8.8	24.7	11.0
	16	0.0	2.9	2.9	2.9	2.9	5.9	5.9	0.0	5.9	11.8	2.9	17.6	8.8	14.7	5.9	8.8	22.9	10.3
	17	0.0	2.9	2.9	0.0	11.8	2.9	2.9	5.9	11.8	0.0	5.9	11.8	8.8	11.8	14.7	5.9	22.9	10.2
	18	0.0	5.9	2.9	2.9	5.9	2.9	2.9	2.9	11.8	2.9	2.9	17.6	5.9	17.6	8.8	5.9	22.2	9.9
	19	0.0	2.9	0.0	5.9	8.8	5.9	5.9	2.9	2.9	8.8	2.9	20.6	5.9	11.8	8.8	5.9	21.3	9.5
	20	0.0	2.9	0.0	5.9	2.9	8.8	2.9	0.0	11.8	11.8	8.8	14.7	2.9	11.8	5.9	8.8	21.5	9.6
	21	0.0	3.0	3.0	12.1	0.0	0.0	0.0	15.2	12.1	3.0	6.1	12.1	9.1	9.1	9.1	6.1	21.1	9.4
	22	0.0	0.0	6.1	6.1	0.0	3.0	3.0	6.1	12.1	12.1	6.1	6.1	6.1	21.2	3.0	9.1	22.5	10.1
	23	0.0	0.0	3.7	0.0	7.4	0.0	3.7	7.4	0.0	11.1	18.5	7.4	14.8	3.7	11.1	11.1	24.1	10.8
	24	0.0	0.0	0.0	7.7	0.0	7.7	0.0	0.0	3.8	15.4	11.5	15.4	15.4	11.5	3.8	7.7	24.2	10.8
ALL HOURS		0.0	1.8	2.5	4.7	3.2	3.0	2.3	4.8	5.6	6.6	6.6	16.4	12.5	13.5	7.8	8.8	23.9	10.7

SOURCE: GEORESEARCH, INC.

Table IV - 66

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - BLACKFOOT

(SPRING)

07/30/84 - 10/29/85

		WIND SPEED (MPH)																
			0.1-	2.1-	4.1-	6.1-	8.1-	10.1-	12.1-	14.1-	16.1-	18.1-	20.1-	25.1-	30.1-	35.1-		
		CALM	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	35.0	40.0	>40.0	
								WIND SPEED (METERS/SECOND)										
			0.1-	0.9-	1.8-	2.7-	3.6-	4.5-	5.4-	6.3-	7.2-	8.1-	9.0-	11.2-	13.5-	15.7-		AV	AV
		CALM	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.0	8.9	11.2	13.4	15.6	17.9	>17.9	SPEED (MPH)	SPEED (M/SEC)
	1	0.0	2.2	3.3	13.2	17.6	13.2	6.6	13.2	6.6	6.6	1.1	7.7	4.4	4.4	0.0	0.0	12.8	5.7
	2	0.0	1.1	5.5	14.3	11.0	17.6	7.7	5.5	12.1	6.6	2.2	11.0	3.3	1.1	0.0	1.1	13.1	5.8
	3	0.0	2.2	4.4	9.9	12.1	13.2	14.3	8.8	6.6	6.6	3.3	9.9	4.4	3.3	0.0	1.1	13.6	6.1
	4	0.0	2.2	6.6	8.8	12.1	15.4	13.2	6.6	9.9	1.1	5.5	12.1	2.2	3.3	0.0	1.1	13.4	6.0
	5	0.0	3.3	5.5	11.0	16.5	14.3	9.9	6.6	8.8	4.4	3.3	8.8	4.4	2.2	0.0	1.1	12.7	5.7
	6	0.0	3.3	7.7	12.1	7.7	15.4	9.9	9.9	2.2	6.6	6.6	9.9	3.3	4.4	1.1	0.0	13.5	6.0
	7	0.0	1.2	6.0	10.7	10.7	16.7	13.1	8.3	6.0	3.6	3.6	8.3	6.0	3.6	1.2	1.2	13.8	6.2
	8	0.0	1.2	4.8	10.7	10.7	13.1	8.3	7.1	9.5	3.6	8.3	7.1	4.8	6.0	2.4	2.4	15.4	6.9
H	9	0.0	2.4	1.2	8.3	15.5	9.5	7.1	6.0	2.4	4.8	3.6	20.2	6.0	7.1	4.8	1.2	17.2	7.7
	10	0.0	2.4	2.4	2.4	11.9	13.1	9.5	4.8	7.1	6.0	3.6	16.7	8.3	6.0	3.6	2.4	17.7	7.9
O	11	0.0	1.2	1.2	9.5	3.6	13.1	8.3	6.0	11.9	3.6	4.8	15.5	9.5	9.5	0.0	2.4	17.8	8.0
	12	0.0	1.2	0.0	4.8	9.5	11.9	6.0	7.1	3.6	9.5	8.3	17.9	10.7	7.1	1.2	1.2	18.1	8.1
U	13	0.0	0.0	3.3	4.3	7.6	7.6	6.5	6.5	5.4	16.3	5.4	19.6	8.7	6.5	2.2	0.0	17.9	8.0
	14	0.0	0.0	3.3	7.6	5.4	6.5	5.4	8.7	7.6	14.1	3.3	22.8	6.5	6.5	1.1	1.1	18.0	8.1
R	15	0.0	0.0	2.4	4.7	7.1	4.7	10.6	8.2	7.1	9.4	9.4	18.8	10.6	5.9	0.0	1.2	17.9	8.0
	16	0.0	0.0	1.2	2.4	5.9	8.2	9.4	8.2	10.6	14.1	3.5	21.2	10.6	3.5	1.2	0.0	17.9	8.0
	17	0.0	0.0	1.2	4.7	5.9	4.7	12.9	8.2	10.6	5.9	12.9	18.8	7.1	5.9	1.2	0.0	17.8	7.9
	18	0.0	1.2	0.0	4.7	5.9	9.4	10.6	9.4	14.1	11.8	8.2	15.3	5.9	2.4	1.2	0.0	16.4	7.3
	19	0.0	0.0	1.2	3.5	8.2	16.5	14.1	14.1	8.2	8.2	9.4	11.8	2.4	2.4	0.0	0.0	14.6	6.5
	20	0.0	0.0	2.4	7.1	12.9	22.4	14.1	8.2	9.4	5.9	5.9	8.2	2.4	1.2	0.0	0.0	13.0	5.8
	21	0.0	1.2	2.4	9.4	12.9	16.5	12.9	12.9	5.9	9.4	5.9	5.9	3.5	1.2	0.0	0.0	12.9	5.8
	22	0.0	2.4	2.4	7.1	11.8	18.8	17.6	9.4	10.6	3.5	3.5	8.2	3.5	1.2	0.0	0.0	12.7	5.7
	23	0.0	0.0	2.4	12.0	15.7	21.7	7.2	6.0	10.8	6.0	2.4	9.6	2.4	2.4	1.2	0.0	13.1	5.9
	24	0.0	0.0	4.9	12.3	11.1	17.3	13.6	6.2	7.4	6.2	4.9	9.9	2.5	3.7	0.0	0.0	13.3	5.9
ALL HOURS		0.0	1.2	3.2	8.2	10.4	13.3	10.3	8.2	8.1	7.3	5.3	13.1	5.5	4.2	0.9	0.7	15.2	6.8

SOURCE: GEORESEARCH, INC.

Table IV - 67

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - BLACKFOOT

(SUMMER)

07/30/84 - 10/29/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (METERS/SECOND)														AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.1	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	
	1	0.0	0.0	2.4	12.1	19.4	21.8	13.7	11.3	8.1	3.2	1.6	3.2	0.0	2.4	0.8	0.0	11.2	5.0
	2	0.0	0.0	2.4	14.5	21.0	21.8	15.3	10.5	5.6	3.2	1.6	2.4	0.0	0.8	0.0	0.8	10.6	4.8
	3	0.0	0.0	4.0	17.7	18.5	17.7	17.7	6.5	8.1	4.0	0.8	2.4	0.8	1.6	0.0	0.0	10.6	4.7
	4	0.0	0.0	3.2	12.1	24.2	17.7	16.1	9.7	6.5	4.8	1.6	2.4	0.8	0.8	0.0	0.0	10.7	4.8
	5	0.0	0.0	4.0	18.5	18.5	16.1	13.7	12.9	7.3	4.0	0.8	2.4	0.8	0.0	0.8	0.0	10.4	4.7
	6	0.0	0.0	3.2	19.4	20.2	17.7	12.1	8.1	10.5	0.8	1.6	5.6	0.0	0.8	0.0	0.0	10.5	4.7
	7	0.0	0.8	1.6	18.5	15.3	16.1	13.7	13.7	7.3	4.8	0.0	3.2	3.2	0.8	0.8	0.0	11.4	5.1
	8	0.0	0.0	0.0	12.9	16.1	16.1	14.5	8.9	13.7	3.2	4.0	4.0	5.6	0.0	0.8	0.0	12.7	5.7
H	9	0.0	0.0	0.8	8.1	13.7	13.7	17.7	10.5	9.7	7.3	3.2	8.1	4.0	3.2	0.0	0.0	13.7	6.1
	10	0.0	0.0	0.0	8.1	11.3	13.7	11.3	20.2	8.1	6.5	4.0	8.9	2.4	5.6	0.0	0.0	14.5	6.5
O	11	0.0	0.0	0.0	4.0	11.3	12.9	16.1	14.5	8.9	9.7	4.0	7.3	4.0	6.5	0.8	0.0	15.3	6.8
	12	0.0	0.0	0.0	0.8	11.3	12.9	12.1	13.7	14.5	8.9	6.5	8.9	3.2	6.5	0.8	0.0	15.8	7.1
U	13	0.0	0.0	0.0	1.6	9.6	13.6	8.8	12.8	19.2	7.2	6.4	12.0	4.0	4.0	0.8	0.0	16.0	7.2
	14	0.0	0.0	0.0	1.6	8.0	8.8	21.6	7.2	12.0	12.8	7.2	12.8	3.2	4.8	0.0	0.0	16.0	7.2
R	15	0.0	0.0	0.0	1.6	7.2	8.8	11.2	12.0	12.0	16.0	6.4	14.4	4.0	6.4	0.0	0.0	16.7	7.5
	16	0.0	0.0	0.0	0.8	5.6	12.0	6.4	12.8	8.0	17.6	4.0	22.4	7.2	2.4	0.8	0.0	17.4	7.8
	17	0.0	0.0	0.0	1.6	5.6	12.0	6.4	14.4	9.6	13.6	12.0	16.8	5.6	1.6	0.8	0.0	16.9	7.5
	18	0.0	0.0	1.6	0.8	6.4	12.8	9.6	16.8	12.0	12.0	12.0	10.4	3.2	0.8	1.6	0.0	15.6	7.0
	19	0.0	0.0	0.0	4.8	4.0	14.4	21.6	14.4	10.4	12.0	7.2	9.6	0.0	1.6	0.0	0.0	14.2	6.4
	20	0.0	0.0	0.0	3.2	10.4	17.6	20.0	14.4	13.6	10.4	2.4	4.0	2.4	0.8	0.8	0.0	13.4	6.0
	21	0.0	0.0	0.8	2.4	14.4	22.4	12.8	20.0	10.4	4.8	5.6	4.0	0.8	1.6	0.0	0.0	12.8	5.7
	22	0.0	0.0	0.0	8.1	14.5	21.0	20.2	12.1	8.9	8.1	1.6	3.2	1.6	0.0	0.8	0.0	12.0	5.4
	23	0.0	0.0	0.8	10.6	17.9	25.2	13.0	11.4	8.9	3.3	4.1	3.3	0.8	0.8	0.0	0.0	11.3	5.1
	24	0.0	0.0	0.8	12.2	17.9	29.3	12.2	5.7	8.9	4.1	2.4	4.1	0.0	2.4	0.0	0.0	11.2	5.0
ALL HOURS		0.0	0.0	1.1	8.1	13.4	16.5	14.1	12.3	10.1	7.6	4.2	7.3	2.4	2.3	0.4	0.0	13.4	6.0

SOURCE: GEORESEARCH, INC.

Table IV - 68

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - BLACKFOOT

(AUTUMN)

07/30/84 - 10/29/85

		WIND SPEED (MPH)																	
			0.1-	2.1-	4.1-	6.1-	8.1-	10.1-	12.1-	14.1-	16.1-	18.1-	20.1-	25.1-	30.1-	35.1-			
		CALM	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	35.0	40.0	>40.0		
			WIND SPEED (METERS/SECOND)																
			0.1-	0.9-	1.8-	2.7-	3.6-	4.5-	5.4-	6.3-	7.2-	8.1-	9.0-	11.2-	13.5-	15.7-		AV	AV
		CALM	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.0	8.9	11.2	13.4	15.6	17.9	>17.9	SPEED (MPH)	SPEED (M/SEC)
	1	0.0	1.5	5.2	8.9	5.9	13.3	8.9	10.4	7.4	8.1	5.9	13.3	4.4	3.7	1.5	1.5	15.5	6.9
	2	0.0	1.5	5.2	9.0	10.4	6.7	11.2	9.7	3.0	11.2	7.5	13.4	3.0	2.2	2.2	3.7	15.7	7.0
	3	0.0	0.0	6.1	6.8	13.6	8.3	9.1	8.3	10.6	7.6	5.3	12.1	4.5	2.3	1.5	3.8	15.7	7.0
	4	0.0	0.8	5.3	7.6	13.7	6.9	6.9	10.7	8.4	10.7	4.6	11.5	4.6	3.1	3.8	1.5	15.8	7.1
	5	0.0	0.8	4.7	7.9	9.4	7.9	11.8	11.0	10.2	4.7	9.4	7.1	3.9	7.9	1.6	1.6	16.0	7.2
	6	0.0	2.4	3.2	5.6	12.0	12.0	10.4	8.0	8.0	6.4	8.0	12.8	1.6	4.0	1.6	4.0	15.9	7.1
	7	0.0	1.7	5.1	7.7	10.3	5.1	14.5	6.0	6.8	6.8	11.1	12.0	3.4	4.3	1.7	3.4	16.4	7.3
	8	0.0	1.7	6.9	7.8	6.0	14.7	5.2	5.2	6.9	6.0	5.2	17.2	6.0	6.0	3.4	1.7	16.8	7.5
H	9	0.0	1.7	2.6	9.5	8.6	8.6	3.4	6.0	2.6	7.8	8.6	16.4	11.2	8.6	2.6	1.7	18.4	8.2
	10	0.0	2.7	1.8	8.1	6.3	11.7	4.5	3.6	5.4	2.7	5.4	20.7	12.6	8.1	1.8	4.5	19.3	8.6
O	11	0.0	0.0	2.8	3.7	5.6	12.0	6.5	6.5	5.6	1.9	11.1	16.7	10.2	11.1	3.7	2.8	20.3	9.1
	12	0.0	1.0	1.0	1.0	3.9	13.6	8.7	6.8	8.7	5.8	2.9	16.5	12.6	11.7	3.9	1.9	20.3	9.1
U	13	0.0	1.5	0.0	3.7	6.0	9.0	7.5	7.5	12.7	4.5	3.0	16.4	7.5	15.7	3.7	1.5	19.9	8.9
	14	0.0	1.5	0.7	3.7	6.7	6.7	9.7	6.0	8.2	6.0	7.5	16.4	11.2	9.7	3.7	2.2	19.9	8.9
R	15	0.0	1.7	1.7	2.6	7.8	8.6	3.4	5.2	9.5	6.0	5.2	23.3	14.7	6.0	1.7	2.6	19.7	8.8
	16	0.0	0.0	0.0	6.3	10.7	6.3	4.5	4.5	8.0	14.3	8.9	15.2	9.8	8.0	2.7	0.9	19.0	8.5
	17	0.0	0.9	1.8	7.1	6.3	7.1	3.6	10.7	9.8	11.6	8.9	17.0	7.1	5.4	1.8	0.9	17.8	8.0
	18	0.0	0.9	5.4	3.6	6.3	7.2	9.0	9.9	12.6	7.2	5.4	18.9	8.1	3.6	0.0	1.8	16.7	7.5
	19	0.0	1.8	2.7	6.4	1.8	7.3	10.9	14.5	10.9	8.2	7.3	16.4	7.3	2.7	1.8	0.0	16.6	7.4
	20	0.0	2.7	1.8	5.5	5.5	13.6	5.5	14.5	5.5	10.9	3.6	19.1	5.5	4.5	1.8	0.0	16.2	7.2
	21	0.0	0.0	0.0	8.2	7.3	12.7	8.2	12.7	5.5	14.5	8.2	13.6	1.8	4.5	2.7	0.0	16.0	7.2
	22	0.0	0.0	0.9	9.3	10.3	11.2	10.3	9.3	11.2	6.5	6.5	16.8	1.9	4.7	0.0	0.9	15.4	6.9
	23	0.0	0.0	3.0	9.0	12.0	10.0	10.0	8.0	10.0	7.0	10.0	10.0	4.0	5.0	1.0	1.0	15.3	6.8
	24	0.0	1.1	4.3	6.5	8.6	11.8	9.7	8.6	6.5	10.8	5.4	12.9	5.4	4.3	2.2	2.2	16.0	7.2
ALL HOURS		0.0	1.2	3.1	6.5	8.2	9.6	8.1	8.5	8.1	7.8	6.8	15.2	6.7	6.1	2.2	2.0	17.3	7.7

SOURCE: GEORESEARCH, INC.

Table IV - 69

Annual Wind Rose Distribution

GLACIER COUNTY - BLACKFOOT

07/30/84 - 10/29/85

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1- 0.4
1.1- 2.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.7	0.5- 0.9
2.1- 3.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.0	1.0	1.0- 1.3 S
3.1- 4.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.3	0.0	0.2	0.2	0.2	0.1	0.1	0.1	1.9	1.4- 1.8 P
S 4.1- 5.0	0.2	0.1	0.1	0.1	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.5	0.3	0.3	0.2	3.8	1.9- 2.2 E
P 5.1- 6.0	0.3	0.2	0.1	0.1	0.3	0.2	0.2	0.4	0.3	0.3	0.3	0.5	0.8	0.2	0.3	0.2	4.7	2.3- 2.7 E
E 6.1- 7.0	0.3	0.1	0.1	0.2	0.3	0.2	0.3	0.3	0.5	0.2	0.6	0.5	0.9	0.3	0.3	0.1	5.3	2.8- 3.1 D
E 7.1- 8.0	0.3	0.2	0.2	0.2	0.3	0.4	0.2	0.2	0.3	0.2	0.3	0.8	0.7	0.2	0.2	0.3	4.9	3.2- 3.6
D 8.1- 9.0	0.4	0.2	0.2	0.1	0.5	0.5	0.3	0.4	0.3	0.1	0.4	1.2	0.9	0.1	0.2	0.2	6.0	3.7- 4.0 M
9.1-10.0	0.3	0.1	0.1	0.1	0.3	0.5	0.4	0.3	0.3	0.2	0.5	1.3	1.0	0.1	0.2	0.3	6.0	4.1- 4.5 E
M 10.1-11.0	0.3	0.1	0.0	0.1	0.2	0.4	0.4	0.3	0.2	0.2	0.3	1.1	0.6	0.2	0.2	0.3	4.8	4.6- 4.9 T
I 11.1-12.0	0.2	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.3	0.2	0.4	0.9	0.6	0.1	0.2	0.3	4.8	5.0- 5.4 E
L 12.1-13.0	0.2	0.0	0.1	0.0	0.3	0.3	0.3	0.4	0.2	0.1	0.5	1.1	0.6	0.1	0.1	0.3	4.6	5.5- 5.8 R
E 13.1-14.0	0.2	0.0	0.0	0.0	0.1	0.1	0.3	0.3	0.2	0.2	0.4	1.0	0.7	0.1	0.2	0.2	4.0	5.9- 6.3 S
S 14.1-15.0	0.2	0.1	0.0	0.0	0.1	0.2	0.2	0.4	0.3	0.1	0.5	1.1	0.5	0.1	0.1	0.1	3.9	6.4- 6.7 /
/ 15.1-16.0	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.2	0.2	0.4	1.1	0.5	0.1	0.1	0.1	3.7	6.8- 7.2 S
H 16.1-17.0	0.2	0.0	0.0	0.0	0.0	0.3	0.2	0.4	0.2	0.1	0.5	0.8	0.5	0.0	0.1	0.2	3.4	7.3- 7.6 E
O 17.1-18.0	0.1	0.0	0.1	0.0	0.0	0.1	0.2	0.3	0.1	0.1	0.6	1.1	0.5	0.1	0.1	0.2	3.4	7.7- 8.0 C
U 18.1-19.0	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.3	0.1	0.1	0.5	0.8	0.5	0.0	0.0	0.1	2.8	8.1- 8.5 O
R 19.1-20.0	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.2	0.1	0.4	0.8	0.3	0.0	0.0	0.1	2.5	8.6- 8.9 N
20.1-25.0	0.3	0.0	0.0	0.0	0.1	0.2	0.7	1.3	0.5	0.3	1.8	3.8	1.2	0.0	0.1	0.3	10.7	9.0-11.2 D
25.1-30.0	0.1	0.0	0.0	0.0	0.0	0.1	0.6	0.9	0.3	0.2	1.4	2.7	0.9	0.0	0.0	0.1	7.4	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.6	0.2	0.1	0.6	2.1	0.5	0.0	0.0	0.0	4.7	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.1	0.0	0.1	1.4	0.2	0.0	0.0	0.0	2.7	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.1	0.0	0.1	0.9	0.2	0.0	0.0	0.0	2.1	>17.9
CALM																	0.0	CALM
TOTAL	4.1	1.6	1.3	1.1	3.2	4.7	6.4	9.6	5.8	3.3	11.1	25.3	13.5	2.4	2.8	3.9	100.0	TOTAL
AV SPEED (MPH)	11.6	9.4	9.8	8.0	9.1	12.7	17.8	20.1	14.0	13.3	17.9	20.1	15.2	9.6	9.8	12.3	16.1	AV SPEED (MPH)
AV SPEED (M/SEC)	5.2	4.2	4.4	3.6	4.1	5.7	7.9	9.0	6.3	5.9	8.0	9.0	6.8	4.3	4.4	5.5	7.2	AV SPEED (M/SEC)

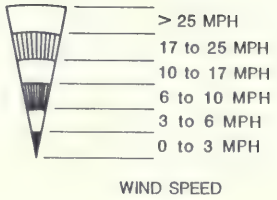
SOURCE: GEORESEARCH, INC.

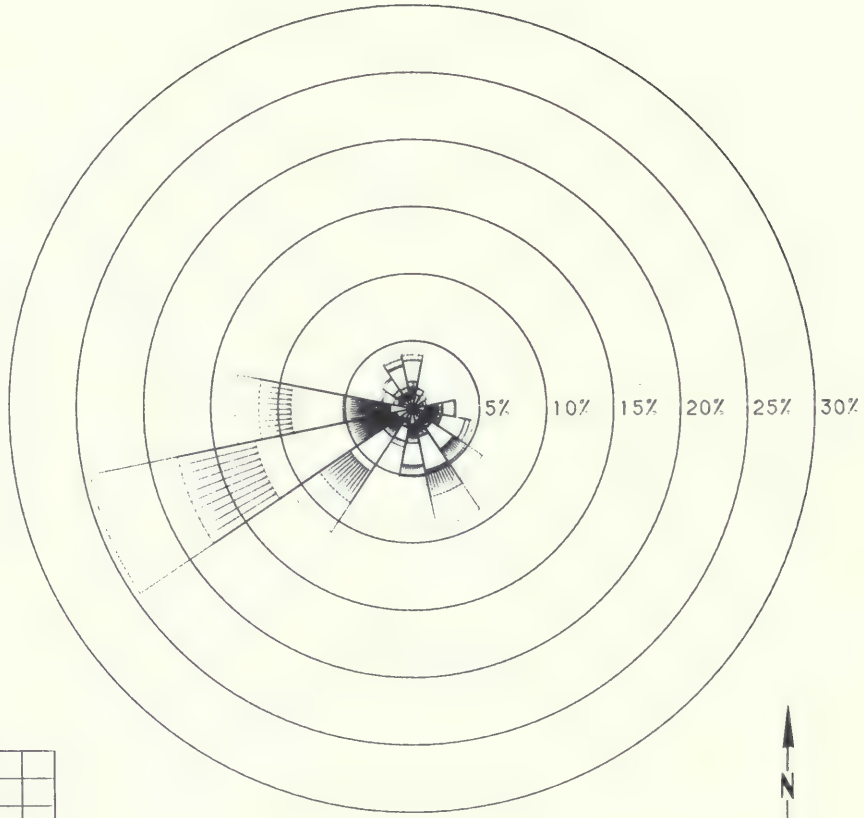
Figure IV - 7

Annual Wind Rose

GLACIER COUNTY - BLACKFOOT

(1984 - 1985)





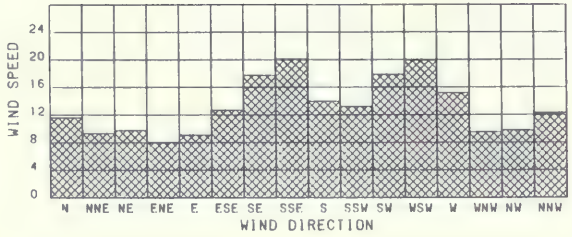


Table IV - 70

Coefficients of Weibull Distribution

GLACIER COUNTY - BLACKFOOT

07/30/84 - 10/29/85

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	12.3355	1.6922
FEBRUARY	13.0648	2.3182
MARCH	6.2717	1.7252
APRIL	9.6212	1.9089
MAY	5.5429	2.4051
JUNE	5.5284	2.2757
JULY	5.1009	2.7248
AUGUST	6.3942	2.4234
SEPTEMBER	7.4238	1.9164
OCTOBER	8.5875	1.7505
NOVEMBER	9.2984	1.8151
DECEMBER	12.4529	1.8769
YEAR	7.3608	1.8587

SOURCE: GEORESEARCH, INC.

CUT BANK
GLACIER COUNTY

The Cut Bank site is located in a gently rolling area about 12 miles north of Cut Bank at 48 47 54 N and 112 19 37 W (Site No. 55 on Map II-1). Elevation at the site is 4,120 feet. This site was established by the Bureau of Reclamation as part of its Northern Great Plains Wind Energy Study. The Department of Natural Resources and Conservation assumed responsibility for the monitoring site in October 1982.

The site is on the Great Plains about 40 miles east of the Rocky Mountain Front and about 50 miles west of the Sweetgrass Hills. The land in the area is used predominantly for agriculture. While most of the land is privately owned, there are a few sections of state and federal land. The Blackfeet Indian Reservation lies a few miles to the west. Interstate Highway 15 runs near the site, and many county roads cross the area.

Electrical service in the Cut Bank area is provided by Glacier County Electric Cooperative. A 115-kV transmission line runs east-west through Cut Bank. The nearest commercial airport is at Cut Bank, approximately 15 miles to the south. Air traffic in the area generally is light.

Collection of wind data began on June 3, 1981, and continued through August 3, 1983. Data from the wind sensors were continuously recorded on cassette tape at the site. These tapes were further processed by computer to yield hourly averages of wind speed, wind direction, the average cube of the hourly speed, and standard deviation of the hourly speed. In addition, the maximum and minimum instantaneous values of wind speed during each hour were recorded. Anemometer height was 10 meters. A bushy wind break, house, and ranch buildings within 100 yards to the east and south of the site, as well as a bent and unbalanced wind vane shaft, make the wind direction data highly questionable.

Data recovery was fair to excellent, ranging from 43.3 percent in September to 100.0 percent in April. Overall data recovery for the period was 82.4 percent.

Average monthly wind speeds at this site ranged from 10.5 miles per hour in August to 14.8 miles per hour in May. Average annual wind speed was 12.8 miles per hour.

Average monthly wind power ranged from 96.2 watts/m^2 in August to 306.3 watts/m^2 in January. Average annual wind power was 217.1 watts/m^2.

Average seasonal wind speeds were 12.2 miles per hour in summer, 12.3 miles per hour in autumn, 13.2 miles per hour in winter, and 13.5 miles per hour in spring. In winter, the highest average wind speeds occurred in mid-afternoon. In spring and autumn, the highest average wind speeds occurred in late afternoon, and in summer they occurred in early evening. The lowest average wind speeds occurred around 0500 to 0800 MST year round. The diurnal range of average wind speeds was greatest in summer and least in winter.

The most common wind directions were west, west-northwest, and south. Winds from the east and east-southeast were least common. By direction, average wind speeds ranged from 8.6 miles per hour for southwest winds to 15.8 miles per hour for westerly winds.

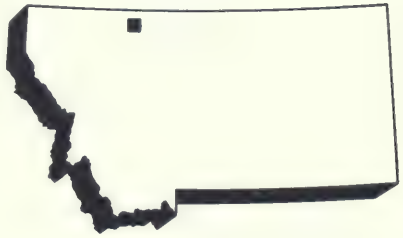


Table IV - 71

Monthly Wind Speed Distribution

GLACIER COUNTY - CUT BANK

06/03/81 - 08/03/83

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	0.4	2.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.5
0.1-1.0	0.9	2.8	1.2	0.2	0.0	0.1	0.1	0.3	0.2	0.2	0.4	0.7	0.6
1.1-2.0	2.8	3.9	2.6	0.7	0.2	0.6	0.2	1.9	0.6	0.8	1.1	2.5	1.5
2.1-3.0	3.9	2.6	2.7	1.5	0.6	1.5	1.0	2.5	2.2	2.4	1.7	2.4	2.1
3.1-4.0	5.5	3.6	3.1	4.3	2.0	2.7	3.2	5.8	5.4	4.9	3.3	3.5	3.8
4.1-5.0	6.3	3.6	3.8	3.4	2.2	3.4	4.0	5.8	5.4	5.3	4.4	4.0	4.2
5.1-6.0	6.4	5.6	4.7	5.7	4.8	6.5	6.7	7.7	5.0	6.5	4.8	6.5	6.0
6.1-7.0	3.4	3.9	4.3	5.9	3.7	5.3	7.1	6.8	6.4	5.0	5.7	5.8	5.2
7.1-8.0	4.7	4.5	6.4	6.5	6.5	7.7	7.5	9.6	5.4	7.0	7.9	6.3	6.7
8.1-9.0	3.8	4.3	4.1	6.3	4.8	5.5	6.6	6.5	5.1	4.9	6.7	4.0	5.2
9.1-10.0	5.2	6.7	6.5	6.4	5.9	6.5	7.7	8.0	6.3	6.0	7.8	6.9	6.7
10.1-11.0	4.0	3.8	5.1	5.2	4.8	4.9	5.8	3.9	5.0	4.8	4.7	4.4	4.7
11.1-12.0	5.4	5.1	6.5	6.9	6.5	6.6	6.4	6.3	6.6	7.0	6.5	7.5	6.4
12.1-13.0	4.0	4.3	6.5	5.5	4.7	4.4	5.9	4.5	6.6	4.5	3.8	4.3	4.8
13.1-14.0	3.6	3.9	6.1	5.2	5.9	5.7	5.7	4.5	5.9	5.1	4.9	5.0	5.1
14.1-15.0	3.2	3.9	4.6	4.2	4.8	4.2	4.4	4.2	4.3	3.9	4.5	3.1	4.1
15.1-16.0	3.3	2.8	4.8	2.4	4.7	4.4	3.4	2.9	4.0	3.9	3.2	3.5	3.6
16.1-17.0	3.6	3.6	4.9	3.5	5.7	5.4	2.6	4.8	4.5	3.9	4.6	3.7	4.2
17.1-18.0	2.6	3.0	3.2	2.3	3.3	3.5	2.6	2.6	2.9	4.1	2.7	2.4	2.9
18.1-19.0	3.6	3.0	3.6	3.3	3.8	3.4	3.3	2.6	3.0	3.3	3.6	3.1	3.3
19.1-20.0	1.8	1.5	2.6	2.2	3.0	2.9	2.1	1.7	1.4	2.2	2.0	1.6	2.1
20.1-25.0	8.5	10.3	8.5	8.3	12.4	8.5	8.3	6.3	9.3	7.9	8.3	8.5	8.7
25.1-30.0	7.2	5.3	2.8	6.2	5.7	4.2	2.8	0.7	2.6	4.1	3.4	4.7	4.3
30.1-35.0	3.4	2.9	0.7	2.3	2.8	1.8	1.5	0.0	1.3	2.0	0.9	3.0	2.0
35.1-40.0	1.1	1.6	0.2	1.0	1.2	0.2	0.4	0.0	0.5	0.2	0.2	1.4	0.7
>40.0	1.3	0.5	0.3	0.8	0.1	0.1	0.8	0.0	0.0	0.0	0.1	1.2	0.5
AVERAGE SPEED (MPH)	13.4	12.9	12.4	13.5	14.8	13.1	12.6	10.5	12.3	12.5	12.0	13.3	12.8
AVERAGE SPEED (M/SEC)	6.0	5.8	5.6	6.0	6.6	5.8	5.6	4.7	5.5	5.6	5.4	6.0	5.7
AVERAGE WIND POWER (WATTS/M**2)	306.3	271.8	176.5	255.0	264.9	188.5	184.2	96.2	165.7	183.3	167.3	291.3	217.1
PERCENT DATA RECOVERY	99.6	98.3	91.4	100.0	79.1	78.4	64.6	71.4	43.3	80.1	95.7	99.9	82.4

SPEED (MPH)
CALM
0.1- 0.4
0.5- 0.9
1.0- 1.3
1.4- 1.8
1.9- 2.2
2.3- 2.7
2.8- 3.1
3.2- 3.6
3.7- 4.0
4.1- 4.5
4.6- 4.9
5.0- 5.4
5.5- 5.8
5.9- 6.3
6.4- 6.7
6.8- 7.2
7.3- 7.6
7.7- 8.0
8.1- 8.5
8.6- 8.9
9.0-11.2
11.3-13.4
13.5-15.6
15.7-17.9
>17.9

SPEED / HOUR

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 15672
PERCENTAGE DATA RECOVERY = 82.4

SOURCE: GEORESEARCH, INC.

Table IV - 72

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK (WINTER)

06/03/81 - 08/03/83

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
								WIND SPEED (METERS/SECOND)										AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	1.1	4.4	10.0	8.3	7.8	13.9	8.3	6.1	8.3	7.2	6.7	10.6	2.2	2.8	0.6	1.7	13.0	5.8
	2	1.1	2.8	11.1	7.8	16.1	6.1	7.2	11.1	7.2	5.6	4.4	11.1	2.8	3.3	1.1	1.1	12.9	5.7
	3	1.7	4.4	8.9	12.2	6.7	14.4	12.2	6.7	5.0	5.6	6.7	9.4	3.3	1.7	0.0	1.1	12.1	5.4
	4	1.1	5.6	6.7	17.8	9.4	9.4	10.0	10.6	7.8	4.4	2.8	5.0	5.6	2.8	0.0	1.1	11.8	5.3
	5	1.1	5.6	7.2	13.3	12.8	11.1	10.6	11.7	6.1	3.3	1.7	8.3	3.3	2.2	0.6	1.1	11.7	5.3
	6	0.6	5.0	8.9	14.4	12.2	8.9	10.6	7.8	8.9	6.7	2.8	7.2	2.2	2.2	1.1	0.6	11.7	5.2
	7	0.6	3.4	10.1	11.7	10.1	14.5	13.4	7.8	6.1	7.3	3.4	6.1	1.7	1.7	1.7	0.6	11.5	5.1
	8	0.6	5.1	7.9	15.2	11.8	11.2	12.9	8.4	3.4	7.9	3.9	4.5	3.4	2.8	0.6	0.6	11.5	5.1
H	9	1.1	5.6	10.7	11.2	7.9	17.4	8.4	7.3	2.8	7.9	3.9	7.3	3.9	3.9	0.0	0.6	11.8	5.3
	10	1.7	5.1	7.9	16.9	9.6	9.6	9.6	6.8	5.6	3.4	6.2	7.9	3.4	5.6	0.6	0.0	12.2	5.5
O	11	2.3	6.2	7.3	9.6	14.7	10.2	10.7	4.5	4.5	4.5	4.0	10.2	4.5	5.1	1.7	0.0	12.7	5.7
	12	1.7	5.1	12.5	10.8	9.7	11.4	5.7	6.8	3.4	4.5	6.3	10.2	5.7	4.5	1.1	0.6	12.8	5.7
U	13	1.1	5.0	7.8	15.1	7.3	7.3	8.4	6.7	5.6	5.0	4.5	12.3	8.4	3.9	1.1	0.6	13.7	6.1
	14	2.2	2.8	5.0	15.6	6.7	6.1	6.7	7.8	7.3	5.0	5.6	11.2	7.3	8.4	0.6	1.7	15.1	6.7
R	15	1.7	3.4	5.6	10.1	6.1	6.1	12.3	3.9	6.7	6.1	3.4	14.5	8.9	7.8	1.1	2.2	16.1	7.2
	16	1.1	6.1	2.8	7.8	8.9	4.5	9.5	5.6	5.6	6.7	5.0	21.2	4.5	6.1	2.8	1.7	16.4	7.3
	17	0.6	3.9	4.5	7.8	6.7	9.5	7.3	7.3	6.1	5.6	7.8	18.4	7.8	3.9	1.7	1.1	15.8	7.1
	18	0.6	1.7	5.0	8.4	8.9	8.4	10.6	8.4	6.1	7.3	6.7	15.1	6.1	5.0	1.1	0.6	15.1	6.8
	19	0.6	3.4	4.5	4.5	7.8	15.6	11.2	10.1	10.6	6.7	5.0	10.6	3.9	3.9	1.7	0.0	14.1	6.3
	20	0.6	3.4	3.9	6.1	10.6	10.1	12.3	12.8	9.5	8.9	5.0	8.9	3.4	1.7	2.2	0.6	13.8	6.2
	21	0.0	4.5	5.6	6.1	10.1	12.3	11.2	13.4	7.8	5.6	7.3	9.5	2.8	2.2	0.0	1.7	13.3	5.9
	22	0.0	5.6	5.0	11.2	6.7	10.1	10.1	11.7	7.8	8.4	5.6	11.2	3.4	1.1	1.7	0.6	13.3	5.9
	23	0.6	5.1	8.4	7.9	9.6	10.1	11.8	7.9	7.9	11.2	3.4	7.9	5.1	1.1	1.7	0.6	12.9	5.7
	24	1.1	4.5	6.8	10.7	11.9	7.9	11.9	10.2	7.9	5.1	6.2	9.0	3.4	1.7	1.7	0.0	12.6	5.6
ALL HOURS		1.0	4.5	7.2	10.9	9.6	10.3	10.1	8.4	6.6	6.2	4.9	10.3	4.5	3.6	1.1	0.8	13.2	5.9

SOURCE: GEORESEARCH, INC.

Table IV - 73

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK (SPRING)

06/03/81 - 08/03/83

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
								WIND SPEED (METERS/SECOND)										AV	AV
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	SPEED (MPH)	SPEED (M/SEC)
	1	0.0	1.2	3.6	10.2	12.7	12.0	13.9	7.2	10.2	10.8	7.8	6.0	2.4	1.8	0.0	0.0	12.6	5.6
	2	0.6	0.6	4.2	12.0	12.0	15.7	9.6	9.6	10.8	9.0	4.8	7.2	2.4	1.2	0.0	0.0	12.2	5.5
	3	0.0	1.8	5.4	12.0	14.5	11.4	11.4	13.3	6.0	6.0	4.8	7.8	3.6	0.6	1.2	0.0	12.3	5.5
	4	0.0	3.0	10.2	9.6	11.4	13.9	7.8	13.9	8.4	5.4	4.8	6.6	2.4	1.8	0.6	0.0	11.7	5.2
	5	0.0	2.4	8.4	12.7	17.5	11.4	12.7	10.2	3.6	7.2	6.0	5.4	1.8	0.6	0.0	0.0	10.9	4.9
	6	0.0	3.0	8.4	15.7	17.5	8.4	7.8	10.8	12.0	5.4	6.6	1.8	2.4	0.0	0.0	0.0	10.6	4.7
	7	0.0	3.6	10.2	8.4	21.7	13.9	12.0	6.0	9.0	9.6	1.2	0.6	3.0	0.6	0.0	0.0	10.2	4.6
	8	0.0	3.6	7.8	13.9	12.0	15.7	13.3	12.7	4.2	4.8	5.4	3.0	3.0	0.6	0.0	0.0	10.6	4.7
H	9	0.0	3.6	9.6	9.6	13.3	13.9	12.7	10.2	6.0	6.6	2.4	7.8	1.8	1.8	0.6	0.0	11.3	5.1
	10	0.0	2.4	7.3	8.5	9.1	12.7	13.3	12.1	4.8	6.1	5.5	13.9	2.4	1.2	0.6	0.0	12.8	5.7
O	11	0.0	1.2	4.8	7.3	9.1	9.7	13.9	8.5	9.1	8.5	6.1	13.3	6.1	2.4	0.0	0.0	14.2	6.4
	12	0.0	1.2	4.2	4.2	8.5	9.1	10.9	13.3	12.1	7.9	5.5	13.9	5.5	1.2	1.2	1.2	15.0	6.7
U	13	0.0	1.2	4.2	4.8	6.6	6.6	13.8	17.4	7.8	7.8	8.4	10.8	4.8	3.6	1.8	0.6	15.3	6.8
	14	0.0	1.2	2.4	5.4	9.0	8.4	13.8	10.2	12.6	7.2	3.0	15.0	5.4	3.0	1.8	1.8	15.8	7.1
R	15	0.0	1.2	1.2	7.2	5.4	10.2	13.8	10.8	6.0	9.6	9.0	12.6	6.6	3.0	2.4	1.2	16.0	7.2
	16	0.0	1.8	0.6	7.2	10.8	7.8	12.0	9.6	6.6	7.8	6.0	16.8	6.0	4.8	0.6	1.8	16.1	7.2
	17	0.0	0.6	0.6	7.8	12.0	10.8	7.2	11.4	4.2	6.0	9.0	17.4	7.2	4.2	1.2	0.6	16.0	7.2
	18	0.0	0.6	3.0	6.6	9.0	9.6	8.4	9.0	6.6	6.0	7.2	22.8	4.2	5.4	1.8	0.0	16.2	7.3
	19	0.0	2.4	1.8	4.2	10.2	9.6	10.2	9.6	6.0	7.8	8.4	16.9	7.8	4.8	0.0	0.0	15.9	7.1
	20	0.0	0.6	4.3	2.4	9.8	10.4	9.8	13.4	10.4	7.3	7.3	16.5	3.0	4.3	0.6	0.0	15.1	6.8
	21	0.0	1.8	1.8	6.1	6.7	13.4	12.8	12.8	9.8	10.4	8.5	11.0	3.0	1.8	0.0	0.0	14.0	6.3
	22	0.0	0.6	3.0	6.7	9.1	12.8	16.5	11.6	12.8	6.1	5.5	11.0	3.7	0.6	0.0	0.0	13.4	6.0
	23	0.0	0.0	4.3	6.7	9.1	14.6	10.4	17.1	9.8	11.0	9.1	6.1	0.0	1.8	0.0	0.0	12.9	5.8
	24	0.0	0.6	4.3	9.1	11.6	12.2	12.8	10.4	12.2	6.7	4.3	13.4	0.6	1.8	0.0	0.0	12.8	5.7
ALL HOURS		0.0	1.7	4.8	8.3	11.2	11.4	11.7	11.3	8.4	7.5	6.1	10.7	3.7	2.2	0.6	0.3	13.5	6.0

SOURCE: GEORESEARCH, INC.

Table IV - 74

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK (SUMMER)

06/03/81 - 08/03/83

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (METERS/SECOND)																AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	0.6	3.4	9.1	21.0	17.0	11.4	11.9	11.4	6.8	4.5	1.7	0.6	0.6	0.0	0.0	10.9	4.9
	2	0.0	0.6	3.4	12.5	17.6	15.9	16.5	10.2	8.0	10.2	3.4	1.1	0.0	0.6	0.0	0.0	10.7	4.8
	3	0.0	1.1	5.7	15.3	15.9	19.9	11.9	8.0	8.5	5.1	4.0	3.4	0.6	0.6	0.0	0.0	10.4	4.6
	4	0.0	2.8	10.2	11.4	21.6	15.3	11.9	9.7	5.7	2.8	2.3	5.7	0.6	0.0	0.0	0.0	9.7	4.3
	5	0.0	2.3	8.5	14.8	21.6	14.8	11.9	8.0	8.0	4.0	2.3	2.8	1.1	0.0	0.0	0.0	9.6	4.3
	6	0.0	1.7	14.2	18.8	17.6	13.1	8.0	6.8	5.7	6.3	2.8	4.5	0.6	0.0	0.0	0.0	9.2	4.1
	7	0.0	3.4	13.1	15.9	19.3	11.4	13.1	8.5	4.5	4.5	1.7	4.0	0.0	0.6	0.0	0.0	9.1	4.1
	8	0.0	2.8	17.6	14.8	15.9	10.2	9.7	8.5	4.5	6.3	4.0	5.1	0.6	0.0	0.0	0.0	9.5	4.2
H	9	0.0	2.3	10.8	18.8	14.2	12.5	9.1	8.5	6.3	5.7	3.4	6.8	1.7	0.0	0.0	0.0	10.2	4.6
	10	0.0	2.3	8.0	18.2	16.5	8.0	6.3	10.2	6.3	8.0	6.3	6.3	3.4	0.6	0.0	0.0	11.3	5.0
O	11	0.0	2.3	5.1	10.3	15.4	16.0	7.4	9.7	5.7	7.4	4.6	9.7	3.4	2.9	0.0	0.0	12.4	5.6
	12	0.0	0.0	4.0	15.0	12.1	12.7	9.8	9.2	9.8	5.2	5.8	9.8	3.5	2.9	0.0	0.0	12.9	5.8
U	13	0.0	0.0	4.0	10.8	13.1	11.9	13.1	6.3	8.0	7.4	8.5	10.2	3.4	2.3	1.1	0.0	13.6	6.1
	14	0.0	0.0	2.8	13.1	15.9	9.7	8.5	7.4	4.0	9.1	9.1	11.4	5.1	2.8	0.6	0.6	14.0	6.2
R	15	0.0	0.0	1.1	12.5	14.8	10.2	9.7	9.7	6.8	4.0	7.4	13.6	4.5	4.5	0.6	0.6	14.3	6.4
	16	0.0	0.0	0.6	9.7	10.2	14.2	10.8	13.6	7.4	6.3	5.7	12.5	4.5	2.8	1.1	0.6	14.5	6.5
	17	0.0	0.0	1.7	4.0	11.4	13.1	12.6	10.9	12.6	5.1	7.4	13.7	2.3	4.0	0.0	1.1	14.8	6.6
	18	0.0	0.0	0.0	4.6	11.4	13.7	9.7	12.6	9.7	7.4	6.3	17.7	4.6	1.1	0.0	1.1	15.0	6.7
	19	0.0	0.0	0.6	5.1	8.0	9.7	13.1	8.0	10.9	12.6	8.0	17.7	4.0	1.7	0.0	0.6	15.5	6.9
	20	0.0	0.0	0.6	5.1	6.9	10.3	10.9	12.6	8.6	12.0	9.1	18.3	3.4	1.7	0.0	0.6	15.5	6.9
	21	0.0	0.0	1.7	4.0	6.3	14.3	14.9	13.7	8.0	12.6	8.6	13.7	0.6	0.6	0.6	0.6	14.4	6.4
	22	0.0	0.0	2.3	4.6	12.6	17.1	16.0	15.4	9.7	6.3	4.6	9.1	1.1	0.6	0.0	0.6	12.7	5.7
	23	0.0	0.0	1.7	10.3	13.7	13.1	14.9	16.6	7.4	12.0	5.7	3.4	0.0	0.6	0.6	0.0	12.0	5.4
	24	0.0	1.1	5.7	8.6	13.8	18.4	12.1	10.9	12.6	7.5	5.7	2.3	1.1	0.0	0.0	0.0	11.2	5.0
ALL HOURS		0.0	1.0	5.3	11.1	14.5	13.4	11.4	10.3	7.9	7.3	5.5	8.5	2.1	1.3	0.2	0.3	12.2	5.5

SOURCE: GEORESEARCH, INC.

Table IV - 75

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK (AUTUMN)

06/03/81 - 08/03/83

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
								WIND SPEED (METERS/SECOND)										AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.7	2.2	4.5	13.4	14.2	17.9	10.4	11.9	8.2	6.7	2.2	7.5	0.0	0.0	0.0	0.0	10.8	4.8
	2	0.7	1.5	6.7	11.2	15.7	12.7	17.2	12.7	5.2	6.0	6.0	4.5	0.0	0.0	0.0	0.0	10.7	4.8
	3	0.7	4.5	6.7	10.4	13.4	16.4	14.9	8.2	4.5	9.0	7.5	3.0	0.7	0.0	0.0	0.0	10.6	4.7
	4	0.8	1.5	8.3	14.3	16.5	15.0	8.3	9.8	5.3	7.5	1.5	9.0	2.3	0.0	0.0	0.0	10.7	4.8
	5	0.8	0.8	9.1	15.2	13.6	16.7	15.2	7.6	6.8	6.1	3.0	3.0	1.5	0.8	0.0	0.0	10.2	4.6
	6	0.8	0.8	12.1	14.4	16.7	9.8	13.6	6.8	11.4	6.1	3.0	3.0	1.5	0.0	0.0	0.0	10.1	4.5
	7	0.8	2.3	10.6	13.6	18.2	13.6	7.6	11.4	4.5	7.6	3.0	4.5	2.3	0.0	0.0	0.0	10.1	4.5
	8	0.8	1.5	9.8	18.2	14.4	13.6	9.1	5.3	9.1	4.5	3.0	9.1	1.5	0.0	0.0	0.0	10.3	4.6
H	9	0.8	3.0	8.3	15.9	22.0	7.6	6.8	9.1	4.5	6.8	7.6	6.1	0.8	0.8	0.0	0.0	10.5	4.7
	10	0.8	3.0	15.2	13.6	10.6	12.1	12.9	8.3	3.8	6.1	3.8	8.3	0.8	0.8	0.0	0.0	10.2	4.6
O	11	1.5	2.3	11.4	16.7	10.6	11.4	9.1	6.1	8.3	7.6	3.0	9.8	1.5	0.8	0.0	0.0	10.8	4.8
	12	1.5	1.5	7.6	12.9	14.4	10.6	6.1	6.1	5.3	8.3	5.3	16.7	3.8	0.0	0.0	0.0	12.4	5.6
U	13	1.5	0.0	6.7	9.0	13.4	6.0	13.4	8.2	4.5	7.5	8.2	13.4	6.0	2.2	0.0	0.0	13.8	6.2
	14	1.5	0.0	3.7	8.2	9.7	12.7	9.0	6.0	6.0	9.0	9.7	15.7	2.2	6.0	0.7	0.0	14.9	6.7
R	15	1.5	0.0	2.2	5.2	9.7	11.2	7.5	11.2	11.2	7.5	7.5	11.2	9.0	3.7	0.7	0.7	15.7	7.0
	16	1.5	0.0	3.7	5.2	6.0	7.5	7.5	17.2	9.0	7.5	5.2	17.2	4.5	7.5	0.7	0.0	16.1	7.2
	17	1.5	0.7	3.0	4.5	6.7	9.0	6.7	11.9	10.4	9.0	7.5	16.4	6.0	6.0	0.7	0.0	16.1	7.2
	18	1.5	0.7	4.5	5.2	4.5	6.0	10.4	11.9	12.7	9.0	9.0	13.4	8.2	2.2	0.7	0.0	15.6	7.0
	19	1.5	0.0	2.2	8.2	5.2	9.7	11.9	12.7	9.7	9.0	8.2	14.2	4.5	3.0	0.0	0.0	14.7	6.6
	20	1.5	0.0	3.0	6.0	9.0	15.7	12.7	12.7	11.9	10.4	4.5	6.7	4.5	0.7	0.7	0.0	13.3	5.9
	21	1.5	0.0	1.5	5.3	15.0	15.0	15.0	11.3	12.8	7.5	5.3	6.8	3.0	0.0	0.0	0.0	12.4	5.6
	22	1.5	0.0	1.5	6.0	18.8	15.0	20.3	9.8	7.5	8.3	2.3	9.0	0.0	0.0	0.0	0.0	11.7	5.2
	23	1.5	0.8	7.5	7.5	12.0	17.3	16.5	9.8	8.3	6.0	7.5	4.5	0.8	0.0	0.0	0.0	11.1	5.0
	24	1.5	0.8	4.5	9.8	13.6	20.5	13.6	9.1	7.6	9.1	3.8	6.1	0.0	0.0	0.0	0.0	11.1	4.9
ALL HOURS		1.2	1.2	6.4	10.4	12.6	12.6	11.5	9.8	7.9	7.6	5.3	9.1	2.7	1.4	0.2	0.0	12.3	5.5

SOURCE: GEORESEARCH, INC.

Table IV - 76

Annual Wind Rose Distribution

GLACIER COUNTY - CUT BANK

06/03/81 - 08/03/83

DIRECTION> / SPEED (MPH)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION / SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.6	0.1- 0.4
1.1- 2.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	1.6	0.5- 0.9
2.1- 3.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.1	0.3	0.2	0.1	2.1	1.0- 1.3 S
3.1- 4.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.4	0.3	0.5	0.5	0.3	0.3	0.3	0.2	3.9	1.4- 1.8 P
S 4.1- 5.0	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.2	4.2	1.9- 2.2 E
P 5.1- 6.0	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.5	0.5	0.6	0.5	0.6	0.5	0.4	0.3	6.0	2.3- 2.7 E
E 6.1- 7.0	0.3	0.2	0.3	0.2	0.2	0.2	0.1	0.2	0.4	0.4	0.4	0.4	0.5	0.6	0.4	0.3	5.2	2.8- 3.1 D
E 7.1- 8.0	0.4	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.6	0.5	0.5	0.5	0.6	0.6	0.6	0.4	6.7	3.2- 3.6
D 8.1- 9.0	0.4	0.2	0.2	0.3	0.2	0.1	0.3	0.3	0.5	0.3	0.3	0.3	0.4	0.5	0.5	0.4	5.2	3.7- 4.0 M
9.1-10.0	0.4	0.3	0.4	0.4	0.2	0.2	0.3	0.5	0.8	0.5	0.4	0.3	0.6	0.6	0.4	0.4	6.7	4.1- 4.5 E
M 10.1-11.0	0.3	0.3	0.4	0.3	0.1	0.1	0.2	0.4	0.5	0.3	0.3	0.2	0.4	0.4	0.3	0.2	4.7	4.6- 4.9 T
I 11.1-12.0	0.4	0.3	0.5	0.4	0.2	0.1	0.2	0.6	0.8	0.4	0.3	0.3	0.6	0.6	0.5	0.4	6.5	5.0- 5.4 E
L 12.1-13.0	0.3	0.3	0.4	0.3	0.2	0.1	0.2	0.6	0.6	0.2	0.2	0.3	0.4	0.4	0.4	0.2	4.8	5.5- 5.8 R
E 13.1-14.0	0.2	0.3	0.3	0.3	0.2	0.1	0.3	0.5	0.5	0.3	0.2	0.2	0.5	0.5	0.4	0.3	5.1	5.9- 6.3 S
S 14.1-15.0	0.2	0.3	0.3	0.2	0.2	0.1	0.2	0.5	0.4	0.2	0.1	0.2	0.3	0.5	0.3	0.1	4.1	6.4- 6.7 /
/ 15.1-16.0	0.2	0.2	0.4	0.2	0.1	0.1	0.1	0.3	0.3	0.1	0.1	0.1	0.3	0.4	0.3	0.2	3.6	6.8- 7.2 S
H 16.1-17.0	0.2	0.3	0.3	0.3	0.1	0.1	0.2	0.4	0.4	0.1	0.1	0.2	0.5	0.4	0.4	0.2	4.2	7.3- 7.6 E
O 17.1-18.0	0.2	0.2	0.2	0.1	0.0	0.0	0.1	0.3	0.2	0.0	0.1	0.2	0.4	0.3	0.2	0.1	2.9	7.7- 8.0 C
U 18.1-19.0	0.2	0.3	0.3	0.1	0.1	0.0	0.1	0.3	0.3	0.0	0.1	0.2	0.5	0.4	0.3	0.1	3.3	8.1- 8.5 O
R 19.1-20.0	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.1	0.2	0.3	0.3	0.2	0.1	2.1	8.6- 8.9 N
20.1-25.0	0.4	0.7	0.4	0.3	0.1	0.0	0.3	0.7	0.6	0.1	0.1	0.7	1.5	1.3	1.0	0.3	8.7	9.0-11.2 D
25.1-30.0	0.1	0.3	0.2	0.1	0.0	0.0	0.2	0.2	0.4	0.0	0.0	0.4	0.9	0.7	0.6	0.1	4.2	11.3-13.4
30.1-35.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0	0.2	0.6	0.3	0.2	0.1	2.0	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.8	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.4	>17.9
CALM																	0.5	CALM
TOTAL	5.0	5.2	5.6	4.7	3.1	2.4	4.1	7.2	9.6	5.3	5.3	7.0	11.5	10.5	8.3	4.6	100.0	TOTAL
AV SPEED (MPH)	12.6	14.5	13.3	11.7	9.8	9.2	12.4	14.3	12.4	8.8	8.6	13.3	15.8	14.3	14.0	11.5	12.8	AV SPEED (MPH)
AV SPEED (M/SEC)	5.6	6.5	5.9	5.2	4.4	4.1	5.6	6.4	5.6	3.9	3.8	6.0	7.1	6.4	6.3	5.1	5.7	AV SPEED (M/SEC)

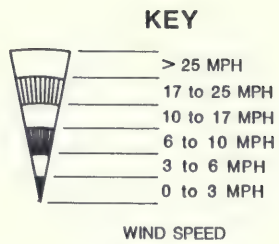
SOURCE: GEORESEARCH, INC.

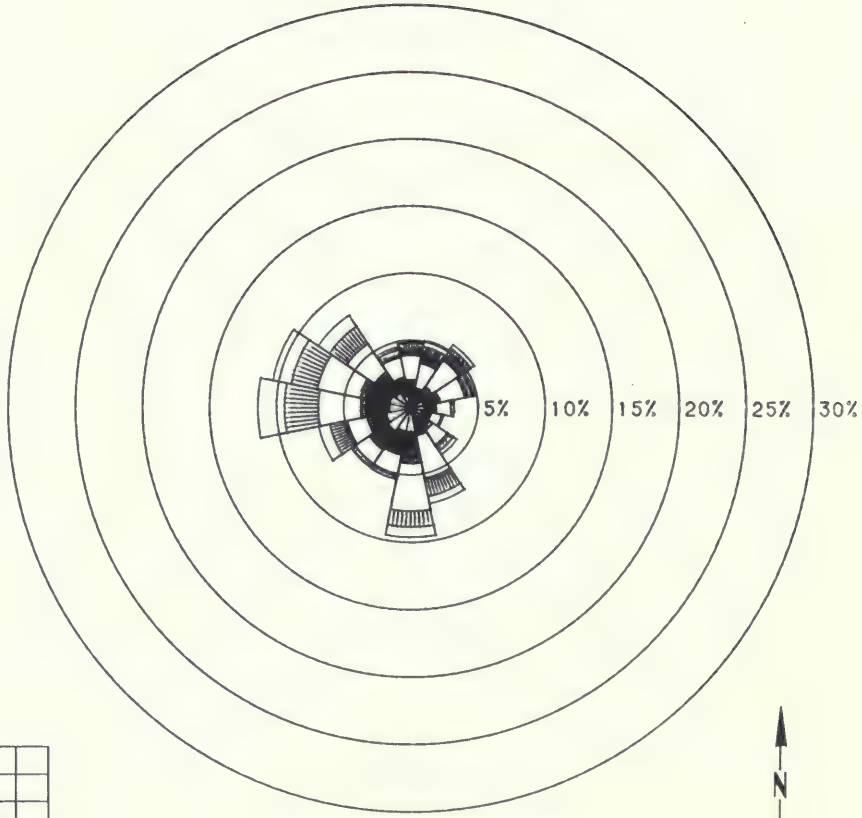
Figure IV - 8

Annual Wind Rose

GLACIER COUNTY - CUT BANK

(1981 - 1983)





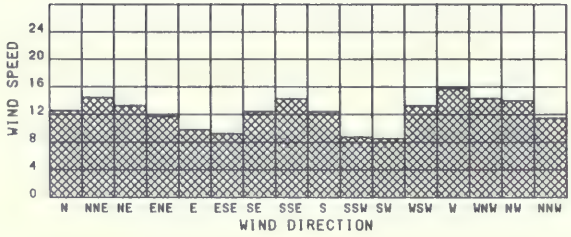


Table IV - 64

Coefficients of Weibull Distribution

GLACIER COUNTY - CUT BANK

06/03/81 - 08/03/83

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	6.5924	1.4589
FEBRUARY	6.7719	1.4816
MARCH	6.3517	1.9743
APRIL	6.1606	1.8728
MAY	7.1095	2.0800
JUNE	6.2660	1.9796
JULY	5.6903	2.0695
AUGUST	5.1465	1.8765
SEPTEMBER	6.0152	1.9066
OCTOBER	6.0286	1.8164
NOVEMBER	5.8882	1.9624
DECEMBER	6.1757	1.7187
YEAR	6.1787	1.8271

SOURCE: GEORESEARCH, INC.

CUT BANK FAA AIRPORT

GLACIER COUNTY

The Cut Bank airport is located about 5 miles south-southwest of Cut Bank at 48 36 00 N and 112 22 12 W (Site No. 56 on Map II-1). Elevation at the airport is 3,852 feet. Meteorological data have been collected at this site for many years by the Federal Aviation Administration.

Cut Bank is on the Great Plains about 40 miles east of the Rocky Mountain Front and about 50 miles west of the Sweetgrass Hills. The land around Cut Bank is used predominantly for agriculture. Most of the land is privately owned, although a few sections are owned by the state and federal governments. The Blackfeet Indian Reservation lies a few miles to the west. Interstate Highway 15 runs near the site, and many county roads cross the area.

Electrical service in the area is provided by Glacier County Electric Cooperative. A 115-kV transmission line runs east-west through Cut Bank. The nearest other commercial airport is at Shelby, approximately 25 miles to the east. Air traffic in the area is generally light.

Data for the site, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data are gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the data set was split into two parts for analysis: November 22, 1949, through October 3, 1959; and October 4, 1959, through December 31, 1978. Only data from the latter period were selected for inclusion in the *Montana Wind Energy Atlas.*

The data set for Cut Bank consists of summaries of observations made every third hour. The anemometer was mounted on a ground mast at a height of 6.1 meters. Data from the site are representative of a large portion of north-central Montana.

Average monthly wind speeds ranged from 10.3 miles per hour in July to 13.9 miles per hour in December and January. Average annual wind speed was 12.5 miles per hour.

Average monthly wind power varied from 118.0 watts/m^2 in July to 328.0 watts/m^2 in January. Average annual wind power was 228.0 watts/m^2.

Average seasonal wind speeds were 10.9 miles per hour in summer, 12.5 miles per hour in autumn, 13.0 miles per hour in spring, and 13.8 miles per hour in winter.

The highest average wind speeds occurred in mid-afternoon during all seasons except summer, when they occurred in late afternoon. The lowest average wind speeds occurred in early morning during all seasons. The diurnal range of average wind speeds was greatest in summer and least in winter.

The most common wind directions at this site were west-southwest and west. Winds from the east-northeast and south-southwest were least common. By direction, average wind speeds ranged from 8.1 miles per hour for winds from the northeast, east, and southeast, to 18.6 miles per hour for winds from the west-southwest. The highest average wind speeds were associated with winds from the prevailing wind directions.

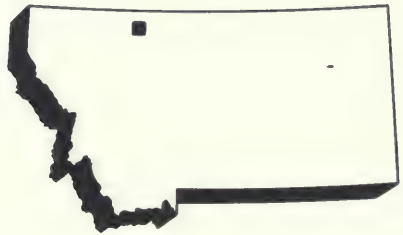


Table IV - 78

Monthly Wind Speed Distribution

GLACIER COUNTY - CUT BANK FAA AIRPORT

10/04/59 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	6.8	6.4	5.6	5.6	4.5	5.2	6.3	7.2	7.9	6.3	6.8	7.3	6.3	CALM (<0.5)
1.1- 3.1	1.1	0.9	1.2	0.7	0.8	0.8	0.8	0.7	1.3	1.1	0.9	1.4	1.0	0.5- 1.4
3.4- 5.4	9.0	9.7	8.7	6.8	6.8	8.6	10.8	10.6	9.8	7.3	8.9	9.1	8.8	1.5- 2.4 S
S 5.6- 7.6	12.1	11.4	12.1	11.3	12.3	14.6	18.4	17.5	14.7	11.7	12.2	10.7	13.2	2.5- 3.4 P
P 7.8- 9.8	10.6	11.4	13.6	13.6	15.3	15.8	18.2	18.0	15.8	11.5	13.0	11.4	14.0	3.5- 4.4 E
E 10.1-12.1	9.7	9.0	11.2	12.1	12.7	12.6	14.5	12.9	12.3	11.6	10.2	8.4	11.4	4.5- 5.4 E
E 12.3-14.3	8.0	8.2	9.0	10.7	10.1	10.0	8.7	9.3	9.9	9.8	8.9	7.6	9.2	5.5- 6.4 D
D 14.5-16.6	6.7	7.8	7.0	8.6	8.7	7.5	6.3	6.5	6.9	7.8	7.1	7.3	7.3	6.5- 7.4
16.8-18.8	7.7	7.7	7.1	8.1	8.4	8.2	5.8	6.4	6.9	8.7	9.8	7.8	7.7	7.5- 8.4 M
M 19.0-21.0	7.7	8.7	7.5	7.9	7.8	6.6	4.5	5.0	5.5	8.6	6.9	7.9	7.0	8.5- 9.4 E
I 21.3-23.3	6.7	7.0	6.3	5.1	5.2	4.3	2.6	2.9	3.9	6.6	5.5	7.7	5.3	9.5-10.4 T
L 23.5-25.5	3.5	3.6	3.4	3.0	2.6	2.0	1.2	1.1	1.5	3.4	3.0	3.9	2.7	10.5-11.4 E
E 25.7-27.7	3.2	2.2	2.3	2.1	1.8	1.3	0.7	0.7	1.5	2.1	2.0	2.5	1.9	11.5-12.4 R
S 28.0-30.0	2.9	2.3	2.1	1.8	1.5	1.4	0.7	0.7	0.9	1.8	2.0	2.7	1.7	12.5-13.4 S
/ 30.2-32.2	1.4	1.5	0.9	1.3	0.7	0.5	0.2	0.1	0.7	0.9	1.2	1.5	0.9	13.5-14.4 /
H 32.4-34.4	1.3	1.0	1.1	0.7	0.4	0.3	0.2	0.2	0.2	0.4	0.6	1.2	0.6	14.5-15.4 S
O 34.7-36.7	0.3	0.2	0.2	0.2	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.1	15.5-16.4 E
U 36.9-38.9	0.4	0.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.5	0.2	16.5-17.4 C
R 39.1-41.2	0.5	0.3	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.4	0.2	17.5-18.4 O
41.4-43.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	18.5-19.4 N
43.6-45.6	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	19.5-20.4 D
45.9-56.8	0.2	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	13.9	13.6	13.2	13.2	12.8	11.9	10.3	10.5	11.2	13.2	13.0	13.9	12.5	
AVERAGE SPEED (M/SEC)	6.2	6.1	5.9	5.9	5.7	5.3	4.6	4.7	5.0	5.9	5.8	6.2	5.6	
AVERAGE WIND POWER (WATTS/M**2)	328.0	303.0	263.0	244.0	209.0	175.0	118.0	121.0	156.0	233.0	258.0	324.0	228.0	

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 79

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK FAA AIRPORT (WINTER)

10/04/59 - 12/31/78

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	8.1	1.3	10.3	12.0	11.7	8.9	7.3	6.6	8.6	7.0	5.8	4.1	2.5	2.7	1.4	1.9	13.1	5.8
	6	8.0	1.3	10.9	11.7	11.6	8.4	8.3	7.1	7.3	6.9	7.2	3.1	2.5	2.0	1.4	2.3	13.0	5.8
O	9	8.9	0.9	11.5	10.6	10.3	8.9	7.9	8.6	6.8	7.7	6.1	3.8	2.6	2.2	1.5	1.8	13.1	5.8
	12	7.2	1.8	9.1	11.1	9.8	6.5	7.1	6.9	7.5	7.4	9.7	4.8	3.2	3.3	1.3	3.5	14.4	6.5
U	15	3.9	1.0	6.8	9.4	10.3	8.3	7.1	7.0	7.9	10.4	9.9	4.1	2.8	4.3	2.2	4.4	15.9	7.1
	18	4.8	0.7	7.6	11.1	12.2	10.2	8.6	7.0	8.6	9.2	7.5	3.1	2.9	2.3	1.4	2.8	14.3	6.4
R	21	6.4	0.9	7.8	12.6	12.4	11.3	9.2	7.6	7.2	9.2	4.7	2.3	2.2	2.3	1.3	2.4	13.3	5.9
	24	7.4	1.3	10.0	12.7	10.3	9.7	8.1	7.2	8.0	6.8	6.5	4.0	2.5	1.8	1.4	2.3	13.2	5.9
ALL HOURS		6.8	1.1	9.3	11.4	11.1	9.0	7.9	7.2	7.7	8.1	7.1	3.7	2.6	2.6	1.5	2.7	13.8	6.2

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 80

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK FAA AIRPORT (SPRING)

10/04/59 - 12/31/78

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																	
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	AV SPEED (MPH)	AV SPEED (M/SEC)
H	3	8.6	1.7	10.0	15.4	15.3	12.0	10.1	7.3	6.1	6.1	3.1	1.4	0.9	0.7	0.5	0.8	10.8	4.8
	6	11.0	1.8	10.4	16.0	14.4	11.9	9.4	6.9	5.2	5.3	3.2	1.9	0.7	0.7	0.5	0.9	10.4	4.7
O	9	9.2	0.9	10.6	12.1	12.6	9.3	9.7	7.1	7.9	7.6	5.4	2.1	1.8	1.8	1.1	0.9	12.2	5.4
	12	2.6	0.5	6.1	9.1	12.8	12.3	8.6	8.4	8.9	9.8	6.3	3.9	3.7	3.3	1.6	2.2	14.9	6.7
U	15	1.5	0.5	4.6	8.7	10.9	10.3	8.8	9.6	9.6	9.6	9.2	5.0	3.3	3.8	2.1	2.7	16.2	7.2
	18	1.6	0.5	4.2	7.2	10.1	10.6	11.5	9.2	10.0	10.5	9.2	5.4	3.8	2.7	1.2	2.4	16.1	7.2
R	21	3.0	0.8	5.8	12.2	17.5	14.8	10.4	9.7	8.7	7.4	4.1	2.8	1.1	0.8	0.6	0.3	12.6	5.6
	24	4.2	0.7	7.7	14.6	19.8	14.8	11.2	6.5	6.5	5.7	3.9	1.5	1.3	0.6	0.4	0.6	11.6	5.2
ALL HOURS		5.2	0.9	7.4	11.9	14.2	12.0	9.9	8.1	7.9	7.7	5.5	3.0	2.1	1.8	1.0	1.3	13.0	5.8

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 81

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK FAA AIRPORT (SUMMER)

10/04/59 - 12/31/78

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	9.4	0.9	14.8	22.5	19.1	12.4	7.8	4.8	3.9	2.0	1.3	0.5	0.3	0.3	0.0	0.1	8.5	3.8
	6	13.5	0.8	16.3	21.3	16.9	12.0	8.4	3.6	3.2	1.9	1.0	0.4	0.4	0.2	0.1	0.1	7.9	3.5
O	9	9.9	1.5	14.0	16.2	14.8	10.2	7.1	7.0	7.4	5.7	2.5	1.7	0.7	0.8	0.2	0.5	10.1	4.5
	12	3.0	0.5	7.4	13.4	16.5	15.2	11.1	7.7	7.9	6.6	5.1	1.8	1.3	1.4	0.4	0.8	12.4	5.5
U	15	2.4	0.5	6.3	11.3	14.7	14.2	10.6	8.6	9.0	8.1	6.4	2.7	1.6	1.8	1.1	0.6	13.6	6.1
	18	2.4	0.6	5.3	11.6	12.3	12.8	9.9	9.7	11.4	10.3	5.6	3.4	1.9	2.0	0.4	0.7	14.0	6.3
R	21	4.1	0.6	6.3	16.7	21.5	14.5	10.7	7.9	7.4	5.1	2.8	0.8	0.6	0.8	0.0	0.2	11.2	5.0
	24	5.5	0.8	9.7	21.9	23.1	15.3	9.1	4.8	3.8	3.0	1.6	0.5	0.4	0.3	0.0	0.1	9.5	4.2
ALL HOURS		6.2	0.8	10.0	16.9	17.4	13.3	9.3	6.8	6.8	5.4	3.3	1.4	0.9	0.9	0.3	0.3	10.9	4.9

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 82

Percentage Frequency Summary for Wind Speed

GLACIER COUNTY - CUT BANK FAA AIRPORT (AUTUMN)

10/04/59 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	10.6	1.3	11.9	14.7	14.0	11.0	9.0	6.7	6.4	5.1	4.0	1.5	1.1	1.3	0.8	0.6	10.7	4.8
	6	12.7	1.5	12.5	15.9	12.5	9.6	8.2	6.7	6.8	5.2	3.9	1.5	1.0	0.7	0.5	0.7	10.2	4.6
O	9	13.1	1.8	12.1	12.8	11.9	9.9	8.4	7.0	7.2	5.8	4.1	2.4	1.4	1.0	0.5	0.4	10.7	4.8
	12	3.6	1.1	7.7	11.8	12.5	10.8	8.7	6.3	8.8	8.3	7.3	4.0	3.0	2.8	1.6	1.5	14.1	6.3
U	15	2.5	0.4	4.8	8.5	10.9	10.8	9.7	8.7	10.5	9.2	8.5	4.5	3.9	3.1	2.1	2.1	15.7	7.0
	18	3.2	0.9	4.5	9.3	13.3	10.0	10.6	8.3	12.1	10.2	8.2	3.8	2.6	1.8	0.8	0.9	14.6	6.5
R	21	4.5	0.5	6.4	13.9	16.8	15.4	12.3	8.1	7.7	6.6	3.3	1.3	0.9	1.3	0.6	0.6	12.0	5.4
	24	5.7	1.2	9.4	16.1	15.6	13.5	9.5	6.4	8.1	5.7	3.4	2.3	1.1	0.8	0.5	0.6	11.4	5.1
ALL HOURS		7.0	1.1	8.7	12.9	13.4	11.4	9.5	7.3	8.5	7.0	5.3	2.6	1.9	1.6	0.9	0.8	12.5	5.6

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 83

Annual Wind Rose Distribution

GLACIER COUNTY - CUT BANK FAA AIRPORT

10/04/59 - 12/31/78

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4
3.4- 5.4	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.8	1.5- 2.4
S 5.6- 7.6	1.1	0.6	0.5	0.2	0.5	0.4	0.8	0.5	0.8	0.3	0.5	0.3	0.8	0.5	0.6	0.4	8.8	2.5- 3.4
P 7.8- 9.8	1.3	0.5	0.6	0.3	0.7	0.6	1.2	0.9	1.2	0.4	0.7	0.7	1.4	1.0	0.9	0.8	13.2	3.5- 4.4
E 10.1-12.1	1.3	0.4	0.3	0.3	0.6	0.6	1.0	1.1	1.0	0.4	0.7	1.0	2.2	1.3	0.9	0.8	13.9	4.5- 5.4
E 12.3-14.3	1.2	0.3	0.2	0.1	0.3	0.3	0.6	0.7	0.5	0.2	0.6	1.2	2.6	1.1	0.7	0.7	11.3	5.5- 6.4
D 14.5-16.6	1.0	0.2	0.1	0.1	0.1	0.2	0.4	0.3	0.3	0.2	0.5	1.3	2.5	0.8	0.5	0.7	9.2	6.5- 7.4
16.8-18.8	0.8	0.2	0.1	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.4	1.3	2.3	0.6	0.4	0.6	7.5	7.5- 8.4
M 19.0-21.0	0.9	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.4	1.6	2.7	0.5	0.4	0.6	7.7	8.5- 9.4
I 21.3-23.3	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4	1.9	2.7	0.3	0.3	0.5	7.0	9.5-10.4
L 23.5-25.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.7	2.0	0.2	0.2	0.4	5.4	10.5-11.4
E 25.7-27.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	1.1	0.1	0.1	0.2	2.7	11.5-12.4
S 28.0-30.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	0.7	0.1	0.0	0.1	1.9	12.5-13.4
/ 30.2-32.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.7	0.0	0.0	0.1	1.7	13.5-14.4
H 32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.7	14.5-15.4
O 34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.5	15.5-16.4
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	16.5-17.4
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
CALM																	6.3	CALM
TOTAL	9.3	2.6	2.0	1.0	2.3	2.3	4.3	3.9	4.1	1.8	5.3	14.3	22.6	6.6	5.1	5.9	99.7	TOTAL
AV SPD (MPH)	12.5	9.2	8.1	8.3	8.1	8.1	8.3	9.2	8.3	9.4	13.6	18.6	16.6	11.9	11.4	13.6	10.9	AV SPD (MPH)
AV SPD (M/S)	5.6	4.1	3.6	3.7	3.6	3.6	3.7	4.1	3.7	4.2	6.1	8.3	7.4	5.3	5.1	6.1	4.9	AV SPD (M/S)

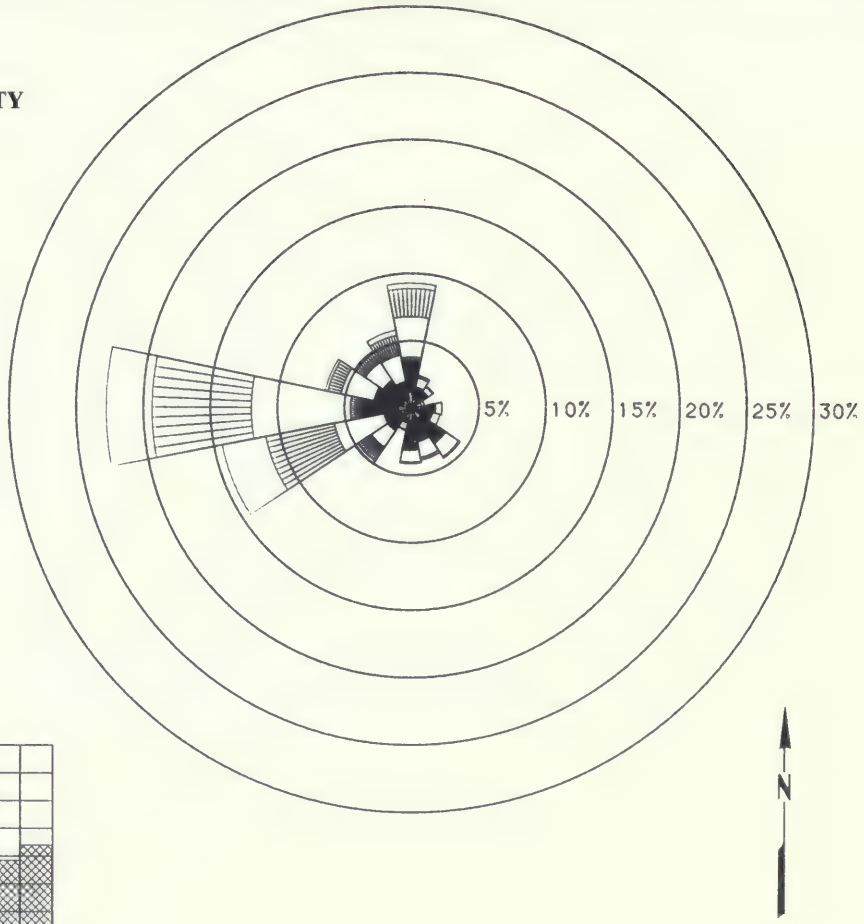
SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

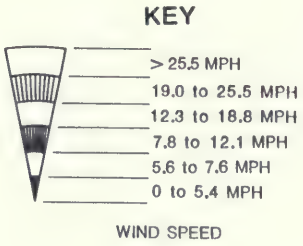
Figure IV - 9

Annual Wind Rose

CUT BANK FAA AIRPORT — GLACIER COUNTY

(1959 - 1978)





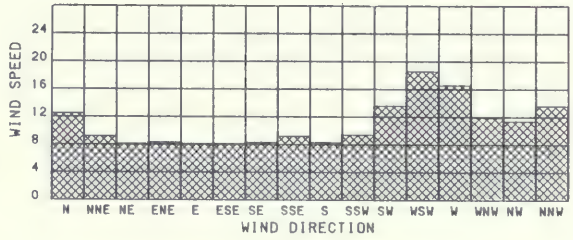


Table IV - 84

Coefficients of Weibull Distribution

GLACIER COUNTY - CUT BANK FAA AIRPORT

10/04/59 - 12/31/78

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.9270	2.1000
FEBRUARY	7.9290	2.1270
MARCH	7.5310	2.1560
APRIL	7.7180	2.3490
MAY	7.3050	2.4670
JUNE	6.9710	2.4340
JULY	6.2700	2.5470
AUGUST	6.3340	2.5960
SEPTEMBER	6.5610	2.3530
OCTOBER	7.3240	2.3990
NOVEMBER	7.6580	2.1690
DECEMBER	7.8490	2.0720
YEAR	7.3750	2.1980

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

DRUMMOND FAA AIRPORT

GRANITE COUNTY

The Drummond Airport is located about 3 miles south-southwest of Drummond at 46 37 10 N and 113 11 50 W (Site No. 59 on Map II-1). Elevation at the airport is 4,238 feet. Meteorological data were collected at the airport for several years by the Federal Aviation Administration.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the data set was split into two parts for analysis: January 1, 1948, through October 15, 1950; and October 16, 1950, through December 31, 1954. Hourly summaries of data from the latter period were used in the *Montana Wind Energy Atlas.* For this period, data were gathered by an anemometer mounted on a ground mast at a height of 8.5 meters.

Since the site is located in a mountain valley, wind data from the site are representative only of the immediate area. The wind across nearby saddles and ridges is believed to be much higher in speed. Attempts by Montana DNRC to measure wind speeds at those sites were hampered by equipment failure and possible vandalism.

Average annual wind speed was 7.2 miles per hour. Average monthly wind speeds varied from 6.0 miles per hour in November to 8.3 miles per hour in April.

Average monthly wind power ranged from 36.0 watts/m^2 in October to 75.0 watts/m^2 in January. Average annual wind power was 52.0 watts/m^2.

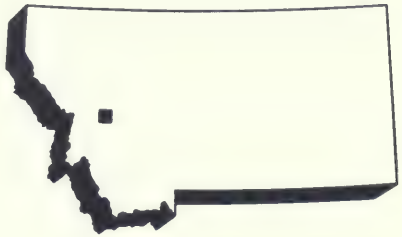


Table IV - 85

Monthly Wind Speed Distribution

GRANITE COUNTY - DRUMMOND FAA AIRPORT

10/16/50 - 12/31/54

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM (<1.1)	8.8	7.2	7.6	4.8	5.9	5.3	6.9	5.8	6.4	9.5	12.8	12.3	8.0	CALM (<0.5)	
1.1- 3.1	7.3	6.6	8.0	6.6	6.7	7.2	6.0	6.5	7.5	10.1	12.2	10.7	8.1	0.5- 1.4	
3.4- 5.4	24.0	23.5	24.3	22.1	24.1	25.6	22.3	24.9	26.2	27.5	27.4	25.6	24.9	1.5- 2.4	S
S 5.6- 7.6	16.3	19.4	18.0	17.1	16.9	17.0	19.6	21.1	21.0	21.9	18.0	18.7	18.8	2.5- 3.4	P
P 7.8- 9.8	12.8	12.5	12.0	12.2	13.4	14.2	16.5	16.4	14.5	11.6	10.3	11.2	13.0	3.5- 4.4	E
E 10.1-12.1	12.1	15.5	14.9	17.9	15.5	16.5	15.0	15.9	13.8	10.6	9.6	12.0	13.9	4.5- 5.4	E
E 12.3-14.3	4.1	4.3	4.3	4.8	4.7	4.2	4.2	3.3	3.5	3.2	3.5	3.1	3.9	5.5- 6.4	D
D 14.5-16.6	4.0	3.5	3.6	5.3	4.0	2.9	3.7	2.6	2.8	2.2	2.0	2.3	3.2	6.5- 7.4	
16.8-18.8	4.9	3.5	3.9	4.7	4.5	4.3	3.4	2.6	2.4	1.7	1.8	2.2	3.2	7.5- 8.4	M
M 19.0-21.0	2.3	1.8	1.5	2.0	2.3	1.5	1.1	0.8	1.1	1.0	0.8	0.8	1.4	8.5- 9.4	E
I 21.3-23.3	1.3	0.8	0.8	1.1	1.1	0.7	0.5	0.2	0.3	0.3	0.5	0.4	0.7	9.5-10.4	T
L 23.5-25.5	0.8	0.6	0.5	0.7	0.3	0.3	0.3	0.0	0.3	0.2	0.4	0.3	0.4	10.5-11.4	E
E 25.7-27.7	0.9	0.5	0.4	0.4	0.4	0.1	0.4	0.0	0.2	0.1	0.3	0.3	0.4	11.5-12.4	R
S 28.0-30.0	0.2	0.2	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	12.5-13.4	S
/ 30.2-32.2	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	13.5-14.4	/
H 32.4-34.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5-15.4	S
O 34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4	E
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4	C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4	O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4	N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4	D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4	
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4	
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4	
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4	
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4	
AVERAGE SPEED (MPH)	7.8	7.6	7.4	8.3	8.1	7.6	7.6	7.2	6.9	6.3	6.0	6.3	7.2		
AVERAGE SPEED (M/SEC)	3.5	3.4	3.3	3.7	3.6	3.4	3.4	3.2	3.1	2.8	2.7	2.8	3.2		
AVERAGE WIND POWER (WATTS/M**2)	75.0	61.0	59.0	71.0	65.0	54.0	51.0	39.0	42.0	36.0	39.0	40.0	52.0		

ANEMOMETER HEIGHT = 28.0 FEET = 8.5 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

HAVRE NWS AIRPORT

HILL COUNTY

The Havre airport is located approximately 4 miles west of Havre at 48 33 00 N and 109 46 30 W (Site No. 60 on Map II-1). Elevation at the airport is 2,585 feet. Meteorological data have been collected at this site for many years by the National Weather Service.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in reporting interval, the data set was split into two parts for analysis: February 1, 1961, through December 31, 1964; and January 1, 1967, through December 31, 1978. Data from the latter period only were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Havre consists of summaries of observations made every third hour from January 1, 1967, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 6.1 meters. The site is representative of a large area of north-central Montana.

Average annual wind speed was 10.7 miles per hour. Average monthly wind speeds ranged from 9.6 miles per hour in August to 11.6 miles per hour in April.

Average annual wind power was 135.0 watts/m^2. Average monthly wind power varied from 96.0 watts/m^2 in August to 170.0 watts/m^2 in April.

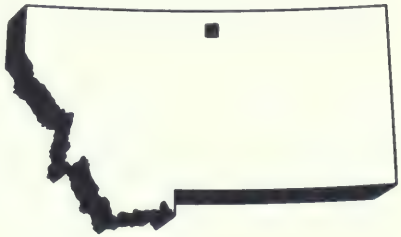


Table IV - 86

Monthly Wind Speed Distribution

HILL COUNTY - HAVRE NWS AIRPORT

01/01/67 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM (<1.1)	5.5	5.1	4.7	3.9	3.5	3.6	3.6	5.3	5.0	6.0	6.4	4.5	4.8
1.1- 3.1	0.3	0.3	0.2	0.2	0.1	0.0	0.1	0.1	0.2	0.1	0.2	0.1	0.2
3.4- 5.4	12.6	12.7	11.9	10.5	11.4	12.7	14.1	15.1	13.8	14.3	14.5	12.6	13.0
5.6- 7.6	16.4	16.2	16.9	16.4	15.5	16.7	19.3	20.4	19.2	16.0	16.6	16.7	17.2
7.8- 9.8	15.5	15.4	16.0	14.7	17.1	17.2	19.0	18.6	18.5	16.6	15.6	15.3	16.6
10.1-12.1	12.8	12.2	12.3	11.7	12.7	12.7	13.1	11.8	12.5	11.9	12.9	13.0	12.5
12.3-14.3	9.3	10.6	10.1	10.9	10.3	11.8	10.1	8.7	9.4	10.0	7.7	9.5	9.8
14.5-16.6	8.7	9.6	8.7	9.8	9.8	8.6	8.9	8.2	7.8	8.4	8.0	8.6	8.8
16.8-18.8	6.4	7.2	7.0	8.4	7.6	6.8	5.4	5.0	6.4	6.3	6.4	6.5	6.6
19.0-21.0	5.3	5.1	5.8	5.9	6.6	5.3	3.6	3.8	4.1	4.5	5.1	4.7	5.0
21.3-23.3	3.0	2.9	2.8	3.0	2.4	2.1	1.2	1.2	1.4	2.5	3.0	3.7	2.4
23.5-25.5	1.9	0.8	1.7	1.2	1.5	1.0	0.7	0.8	0.7	1.6	1.5	1.9	1.3
25.7-27.7	1.4	1.1	0.9	1.7	0.5	0.7	0.6	0.4	0.5	0.6	0.9	1.5	0.9
28.0-30.0	0.6	0.4	0.6	1.0	0.6	0.6	0.3	0.3	0.2	0.6	0.5	0.7	0.5
30.2-32.2	0.2	0.3	0.2	0.2	0.2	0.1	0.0	0.1	0.1	0.3	0.5	0.3	0.2
32.4-34.4	0.1	0.2	0.1	0.3	0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.1	0.1
34.7-36.7	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43.6-45.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	11.0	11.0	11.0	11.6	11.2	10.7	10.1	9.6	10.1	10.5	10.5	11.2	10.7
AVERAGE SPEED (M/SEC)	4.9	4.9	4.9	5.2	5.0	4.8	4.5	4.3	4.5	4.7	4.7	5.0	4.8
AVERAGE WIND POWER (WATTS/M**2)	154.0	144.0	146.0	170.0	140.0	121.0	100.0	96.0	103.0	133.0	146.0	164.0	135.0

CALM (<0.5)	
0.5- 1.4	
1.5- 2.4	S
2.5- 3.4	P
3.5- 4.4	E
4.5- 5.4	E
5.5- 6.4	D
6.5- 7.4	
7.5- 8.4	M
8.5- 9.4	E
9.5-10.4	T
10.5-11.4	E
11.5-12.4	R
12.5-13.4	S
13.5-14.4	/
14.5-15.4	S
15.5-16.4	E
16.5-17.4	C
17.5-18.4	O
18.5-19.4	N
19.5-20.4	D
20.5-25.4	
25.5-30.4	
30.5-35.4	
35.5-40.4	
>40.4	

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

MICROWAVE TOWER

JEFFERSON COUNTY

The Jefferson County Microwave Tower site was located on a hill 2 miles south of East Helena at 46 33 27 N and 111 55 01 W (Site No. 62 on Map II-1). Elevation at the site was 4,360 feet. The site was established by the Montana Air Quality Bureau to measure concentrations of particulates and sulfur dioxide in the area.

Wind data from the site that were available for analysis were collected from January 16, 1975, through December 31, 1981. The data set contains hourly averages of wind speed and wind direction manually reduced from stripchart records. Data were gathered by a Meteorology Research, Inc., mechanical recording anemometer and wind vane. Anemometer height was 4 meters.

Winds have been monitored long enough to adequately represent the wind resource at this location. The data, however, are representative only of a limited area on the northern slopes south of East Helena. Also, data recovery was poor, ranging from 24.1 percent in September to 53.0 percent in May. Overall data recovery was 39.3 percent.

Average monthly wind speeds ranged from 7.2 miles per hour in January to 13.4 miles per hour in December. Average annual wind speed was 10.8 miles per hour.

Average monthly wind power values ranged from 132.1 watts/m^2 in January to 415.3 watts/m^2 in December. Average annual wind power was 237.6 watts/m^2.

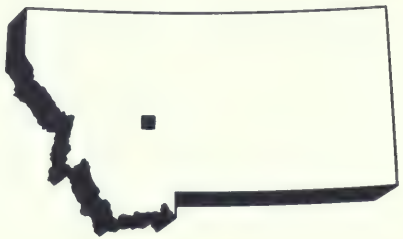


Table IV - 87

Monthly Wind Speed Distribution

JEFFERSON COUNTY - MICROWAVE TOWER

01/16/75 - 12/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	1.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	CALM
0.1-1.0	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1- 0.4
1.1-2.0	11.6	4.8	3.2	0.9	0.4	0.1	0.2	0.3	1.1	1.3	2.0	1.8	2.0	0.5- 0.9
2.1-3.0	14.5	10.2	6.2	3.1	1.5	1.3	1.2	1.7	3.9	3.3	4.9	3.0	4.2	1.0- 1.3
3.1-4.0	11.6	12.6	8.3	4.1	3.2	2.7	4.0	4.0	6.9	5.2	6.4	3.5	5.7	1.4- 1.8
4.1-5.0	9.2	8.4	7.0	5.5	4.5	5.1	5.8	5.9	7.1	4.0	4.4	3.6	5.7	1.9- 2.2
5.1-6.0	6.3	6.1	5.6	6.9	5.4	5.5	7.2	6.6	7.0	4.6	3.2	2.8	5.6	2.3- 2.7
6.1-7.0	4.2	4.4	6.1	7.4	6.2	6.9	7.3	7.0	6.1	4.3	4.0	2.1	5.7	2.8- 3.1
7.1-8.0	3.7	3.8	5.1	6.8	6.2	6.7	8.8	8.1	5.9	4.6	3.8	5.1	5.9	3.2- 3.6
8.1-9.0	3.4	3.4	5.2	6.4	6.6	7.9	7.8	8.4	6.1	6.6	7.2	8.0	6.6	3.7- 4.0
9.1-10.0	3.3	3.5	5.1	7.1	6.7	7.5	6.5	7.9	5.4	7.5	7.6	8.1	6.5	4.1- 4.5
10.1-11.0	4.3	2.4	5.7	6.7	6.6	7.2	5.9	5.9	6.4	7.6	5.5	4.7	5.9	4.6- 4.9
11.1-12.0	4.2	3.3	4.6	6.1	6.2	5.6	6.4	6.6	6.3	5.6	4.1	4.3	5.4	5.0- 5.4
12.1-13.0	3.7	3.5	5.7	5.4	5.8	6.1	6.3	5.3	6.3	6.2	4.9	4.2	5.4	5.5- 5.8
13.1-14.0	3.3	3.6	4.7	5.3	5.0	6.2	5.5	5.7	4.8	4.9	4.5	4.7	4.9	5.9- 6.3
14.1-15.0	2.5	3.3	4.5	4.8	5.5	5.1	4.5	5.0	4.9	5.1	4.5	3.3	4.6	6.4- 6.7
15.1-16.0	1.7	3.8	3.9	4.1	4.1	4.8	4.4	4.4	5.0	4.7	3.8	4.3	4.1	6.8- 7.2
16.1-17.0	1.9	4.2	4.0	3.4	4.9	4.4	3.5	3.9	3.5	4.8	3.5	4.7	3.9	7.3- 7.6
17.1-18.0	1.6	2.6	3.3	3.4	4.6	3.3	4.1	3.8	3.3	3.9	4.1	4.1	3.6	7.7- 8.0
18.1-19.0	1.6	2.4	2.2	3.1	4.5	2.9	2.6	2.3	2.6	3.4	4.2	4.3	3.1	8.1- 8.5
19.1-20.0	0.8	2.2	1.8	2.2	2.6	2.6	2.3	1.7	2.7	3.0	3.4	3.7	2.4	8.6- 8.9
20.1-25.0	3.2	7.9	6.0	5.4	7.9	6.5	5.1	4.6	4.2	8.5	9.4	13.1	6.7	9,0-11.2
25.1-30.0	1.1	2.6	1.5	1.2	1.6	1.4	0.5	0.6	0.5	0.7	2.9	4.6	1.5	11.3-13.4
30.1-35.0	0.2	0.6	0.2	0.4	0.1	0.3	0.0	0.0	0.1	0.1	1.0	1.7	0.4	13.5-15.6
35.1-40.0	0.1	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.1	15.7-17.9
>40.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	7.2	9.7	10.0	10.7	11.7	11.3	10.6	10.5	10.2	11.6	12.1	13.4	10.8	
AVERAGE SPEED (M/SEC)	3.2	4.4	4.5	4.8	5.2	5.1	4.7	4.7	4.5	5.2	5.4	6.0	4.8	
AVERAGE WIND POWER (WATTS/M**2)	132.1	252.9	209.4	226.9	256.0	235.5	188.7	185.0	180.6	246.4	349.8	415.3	237.6	
PERCENT DATA RECOVERY	34.3	32.1	39.8	50.5	53.0	40.7	37.9	51.0	24.1	39.3	40.7	26.9	39.3	

SPEED (MPH)

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
NUMBER OF OBSERVATIONS = 23961
PERCENTAGE DATA RECOVERY = 39.3

SOURCE: GEORESEARCH, INC.

WHITEHALL FAA AIRPORT

JEFFERSON COUNTY

The Whitehall airport site was located 5 miles southwest of Whitehall at 45 49 12 N and 112 12 00 W (Site No. 63 on Map II-1). Elevation at the airport, located in the Jefferson valley, is 4,600 feet. To the south are the Tobacco Root Mountains, which rise to more than 10,000 feet. Bull Mountain, with a summit of about 7,500 feet, lies to the north. West of the site are peaks in the Deerlodge National Forest, with summits ranging from 8,000 to 10,000 feet.

Most of the land in the valley is privately owned. Some sections west of the site are owned by the state. Land in the mountains is controlled predominantly by the Bureau of Land Management and the U.S. Forest Service.

Electrical service in the area is provided by the Montana Power Company and by the Vigilante Electric Cooperative. Many transmission lines run through the area. Commercial airports are located at Whitehall, Butte, Belgrade, and Helena.

Meteorological data were collected at this site for several years by the Federal Aviation Administration. These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. The Battelle data set was derived from hourly observations made from January 1, 1948, through December 31, 1954. The anemometer was mounted on a ground mast at a height of 9.1 meters. The site is representative of a limited area in the Jefferson River Valley. More recent monitoring by Montana DNRC found lower speeds in the immediate area; however, BPA found even higher wind speeds at the microwave tower northeast of town.

Average monthly wind speeds varied from 9.8 miles per hour in August to 17.7 miles per hour in January. Average annual wind speed was 13.2 miles per hour.

Average monthly wind power ranged from 132.0 watts/m² in August to 794.0 watts/m² in January. Average annual wind power was 325.0 watts/m².

Average wind speeds were 10.8 miles per hour in summer, 12.1 miles per hour in autumn, 12.7 miles per hour in spring, and 17.0 miles per hour in winter. During all seasons, the highest average wind speeds occurred in mid-afternoon. The lowest average speeds occurred in mid-morning in winter, and from around 0600 to 0700 MST during the other seasons.

The diurnal range of average wind speeds was greatest in summer and least in winter. Most of the variation in average wind speeds among the seasons was due to differences in the average nighttime wind speed; however, wind speeds were significantly greater during the winter than they were at all hours during the other seasons.

The most common wind directions at the site were south-southwest through southwest. Winds from the east-northeast through south-southeast were least common. By direction, average wind speeds varied from 6.3 miles per hour for winds from the southeast to 22.6 miles per hour for winds from the south-southwest. The highest average wind speeds were those from the most common wind directions.

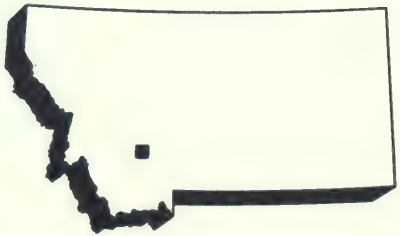


Table IV - 88

Monthly Wind Speed Distribution

JEFFERSON COUNTY - WHITEHALL FAA AIRPORT

01/01/48 - 12/31/54

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM (<1.1)	5.3	4.6	4.7	5.2	5.1	4.7	6.1	6.4	7.2	6.9	6.3	4.1	5.5	CALM (<0.5)	
1.1- 3.1	4.1	3.6	4.2	2.9	3.8	3.6	3.4	4.6	4.1	3.9	3.1	3.0	3.7	0.5- 1.4	
3.4- 5.4	11.8	12.1	14.1	12.9	14.3	13.8	16.0	20.2	19.2	20.1	14.2	11.9	15.1	1.5- 2.4	S
S 5.6- 7.6	5.9	6.1	7.6	7.2	9.1	8.7	10.6	11.6	11.3	10.2	7.6	7.0	8.6	2.5- 3.4	P
P 7.8- 9.8	5.5	5.9	6.7	8.1	10.7	10.6	12.6	12.6	11.0	8.2	6.9	6.4	8.8	3.5- 4.4	E
E 10.1-12.1	9.0	10.4	13.0	16.1	18.4	20.3	19.2	17.0	16.7	13.1	11.8	10.1	14.6	4.5- 5.4	E
E 12.3-14.3	3.0	5.0	6.2	6.8	6.8	6.4	6.1	4.9	4.8	5.5	5.3	4.3	5.4	5.5- 6.4	D
D 14.5-16.6	5.0	5.2	6.9	6.8	6.6	6.6	5.7	5.4	5.6	4.8	5.6	4.5	5.7	6.5- 7.4	
16.8-18.8	7.2	7.1	9.6	9.5	7.9	8.1	6.8	6.0	6.6	6.9	7.5	6.9	7.5	7.5- 8.4	M
M 19.0-21.0	6.3	7.1	7.9	8.5	6.4	6.4	4.7	3.9	4.5	5.4	7.4	7.3	6.3	8.5- 9.4	E
I 21.3-23.3	4.9	5.1	4.3	4.4	3.0	2.8	2.0	1.8	2.5	3.2	4.6	5.0	3.6	9.5-10.4	T
L 23.5-25.5	5.5	4.8	4.0	4.1	2.8	2.6	2.3	1.9	2.2	3.1	4.2	5.1	3.6	10.5-11.4	E
E 25.7-27.7	6.6	7.2	4.3	3.6	2.5	2.7	2.0	1.6	2.2	3.4	4.9	6.8	4.0	11.5-12.4	R
S 28.0-30.0	5.0	4.7	2.8	1.9	1.3	1.3	1.0	0.9	1.0	1.7	4.1	5.7	2.6	12.5-13.4	S
/ 30.2-32.2	2.8	2.9	1.3	0.7	0.4	0.6	0.5	0.3	0.4	0.9	1.4	2.9	1.3	13.5-14.4	/
H 32.4-34.4	3.4	3.3	1.3	0.5	0.4	0.5	0.5	0.4	0.4	0.9	2.0	2.7	1.3	14.5-15.4	S
O 34.7-36.7	1.5	1.4	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.4	0.8	1.4	0.5	15.5-16.4	E
U 36.9-38.9	1.3	1.0	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.3	0.7	1.1	0.4	16.5-17.4	C
R 39.1-41.2	1.4	0.9	0.2	0.2	0.0	0.1	0.1	0.1	0.1	0.3	0.6	1.0	0.4	17.5-18.4	O
41.4-43.4	0.8	0.8	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.4	0.7	0.3	18.5-19.4	N
43.6-45.6	0.8	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.6	0.2	19.5-20.4	D
45.9-56.8	2.1	0.4	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.2	0.3	1.4	0.4	20.5-25.4	
57.0-68.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	25.5-30.4	
68.2-79.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4	
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4	
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4	
AVERAGE SPEED (MPH)	17.7	16.3	13.4	13.0	11.6	11.9	10.7	9.8	10.3	11.6	14.3	17.0	13.2		
AVERAGE SPEED (M/SEC)	7.9	7.3	6.0	5.8	5.2	5.3	4.8	4.4	4.6	5.2	6.4	7.6	5.9		
AVERAGE WIND POWER (WATTS/M**2)	794.0	521.0	295.0	243.0	181.0	182.0	154.0	132.0	143.0	244.0	397.0	623.0	325.0		

ANEMOMETER HEIGHT = 30.0 FEET = 9.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 89

Percentage Frequency Summary for Wind Speed

JEFFERSON COUNTY - WHITEHALL FAA AIRPORT (WINTER)

01/01/48 - 12/31/54

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV SPEED (MPH)	AV SPEED (M/SEC)
			WIND SPEED (M/SEC)																
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	5.7	5.7	14.9	4.0	5.3	10.2	3.8	4.6	7.3	6.7	4.4	4.2	8.4	4.0	1.6	9.3	16.1	7.2
	2	7.3	4.5	11.9	6.7	6.7	9.2	3.8	5.7	7.6	6.0	3.5	5.4	6.5	4.0	1.3	10.0	15.9	7.1
	3	7.0	4.1	14.6	6.7	4.9	10.3	2.5	4.8	7.6	6.0	4.9	6.2	4.6	3.5	3.0	9.4	15.8	7.1
	4	6.6	4.7	15.3	5.1	4.6	9.4	3.4	5.6	4.9	7.3	4.6	5.4	6.8	4.7	1.7	9.8	16.2	7.3
	5	6.5	3.3	15.2	7.9	5.7	9.2	3.7	3.6	5.1	6.0	4.6	6.0	6.0	4.4	2.5	10.3	16.2	7.3
	6	6.2	5.2	12.5	7.0	5.7	11.2	5.0	4.4	5.2	4.6	5.1	3.8	5.9	6.3	3.5	8.4	16.0	7.2
	7	6.4	5.2	14.2	8.9	5.6	9.6	3.9	3.2	6.7	4.9	4.4	5.4	6.8	4.4	2.1	8.4	15.3	6.8
	8	6.5	4.4	17.9	7.5	4.9	9.2	3.8	4.8	5.1	7.0	3.8	4.9	4.8	4.8	2.6	8.2	15.1	6.7
H	9	4.9	5.8	16.2	7.1	7.9	9.5	2.9	4.4	6.2	6.2	4.9	3.8	5.4	3.9	2.9	8.0	15.0	6.7
O	10	5.4	4.1	14.6	8.6	6.4	8.2	2.5	3.6	6.7	7.3	4.9	4.0	6.5	3.5	4.8	9.1	16.2	7.2
	11	5.2	3.5	10.2	7.4	4.1	8.8	3.3	4.1	7.3	6.7	6.2	4.4	7.8	5.2	3.8	11.9	18.1	8.1
U	12	2.9	3.2	9.7	5.3	6.7	7.3	4.3	4.2	5.3	6.0	4.6	6.5	10.3	7.7	3.2	13.1	19.4	8.7
	13	3.3	2.1	7.9	5.4	6.0	6.3	2.8	3.8	7.3	6.1	4.8	6.5	8.4	8.4	4.4	16.5	20.7	9.3
R	14	2.2	1.7	6.8	3.9	5.9	8.4	3.5	3.8	7.2	7.4	5.9	5.6	9.5	8.5	5.9	14.0	21.1	9.4
	15	1.9	1.7	6.8	3.5	4.3	8.4	3.7	4.8	7.9	10.1	4.9	4.8	10.4	7.1	4.4	15.2	21.3	9.5
	16	1.7	1.6	7.8	3.6	5.2	8.4	5.1	5.2	7.5	9.6	6.0	7.9	8.7	7.1	3.5	11.0	20.1	9.0
	17	2.2	1.6	7.8	5.6	5.7	9.9	4.8	7.1	8.2	10.1	5.8	6.2	6.8	6.3	2.5	9.3	18.6	8.3
	18	1.9	1.3	7.9	6.5	7.9	14.1	5.4	6.8	8.5	8.2	5.4	5.7	5.9	3.6	4.0	6.8	17.2	7.7
	19	3.2	2.2	10.3	8.3	7.3	12.5	6.5	6.2	8.4	5.9	5.1	4.5	5.7	4.8	1.6	7.7	16.2	7.2
	20	3.5	3.6	13.0	6.0	5.4	14.0	6.2	6.2	6.9	6.8	4.6	4.4	5.7	3.7	2.4	7.5	15.7	7.0
	21	4.4	3.9	13.6	7.4	7.4	9.8	3.8	6.0	8.4	6.2	5.5	4.6	4.4	5.1	1.7	7.6	15.6	7.0
	22	4.8	3.7	12.4	7.8	5.6	11.6	3.3	5.6	8.6	7.2	5.4	4.3	5.4	3.8	2.2	8.6	16.1	7.2
	23	6.7	4.1	13.0	5.7	6.2	10.6	4.4	4.3	8.3	6.5	4.9	4.1	7.2	4.8	1.6	7.8	15.8	7.1
	24	5.5	4.3	12.0	6.7	6.7	10.0	5.5	4.8	7.3	7.0	5.2	5.5	6.1	4.3	1.9	7.3	15.9	7.1
ALL HOURS		4.7	3.6	11.9	6.3	5.9	9.8	4.1	4.9	7.1	6.9	5.0	5.1	6.9	5.1	2.9	9.8	17.0	7.6

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 90

Percentage Frequency Summary for Wind Speed

JEFFERSON COUNTY - WHITEHALL FAA AIRPORT (SPRING)

01/01/48 - 12/31/54

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
								WIND SPEED (M/SEC)										AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	7.3	4.5	19.1	11.7	8.4	16.8	5.6	5.8	7.0	6.6	2.5	1.0	2.3	0.6	0.0	0.8	10.2	4.6
	2	6.7	5.6	21.9	9.5	10.3	14.9	5.5	5.7	7.3	5.4	3.9	0.7	1.4	0.2	0.5	0.8	9.9	4.4
	3	8.9	5.1	20.8	8.1	9.5	15.8	5.1	5.6	7.5	4.5	2.6	2.1	2.3	0.8	0.5	0.8	10.1	4.5
	4	8.5	7.5	17.5	12.3	7.4	15.1	4.3	5.9	6.2	6.9	2.0	2.3	2.3	1.1	0.6	0.0	10.0	4.5
	5	10.4	6.6	21.1	11.3	7.3	11.2	6.2	5.6	6.7	5.3	1.5	1.9	2.7	1.3	0.2	0.8	9.7	4.3
	6	11.0	6.2	20.5	10.0	7.8	14.3	5.4	4.2	7.3	3.6	2.5	2.8	2.2	1.4	0.3	0.5	9.6	4.3
	7	13.7	6.5	21.6	7.1	8.7	12.7	4.2	4.8	5.8	4.8	2.7	3.6	2.2	0.9	0.2	0.6	9.5	4.2
	8	11.2	6.5	18.2	8.9	7.0	13.4	6.5	5.4	6.0	7.2	2.2	2.3	2.3	1.6	0.3	1.1	10.3	4.6
H	9	6.2	5.1	14.9	8.4	10.1	13.2	6.7	7.1	7.5	6.2	4.5	3.6	3.1	2.0	0.2	1.2	11.9	5.3
	10	3.2	4.3	13.5	8.7	7.2	16.6	6.5	4.8	8.9	6.5	5.3	4.0	4.4	3.3	1.1	1.6	13.4	6.0
O	11	3.4	3.4	10.7	8.0	7.6	15.4	5.9	6.5	8.1	6.2	5.8	3.9	6.5	4.5	0.8	3.3	14.6	6.5
	12	2.8	2.2	11.8	7.5	6.9	15.0	5.6	5.1	8.3	8.4	5.0	6.6	5.3	3.6	2.6	3.3	15.2	6.8
U	13	1.6	1.3	9.5	6.7	8.3	13.4	6.3	6.6	9.2	9.5	5.1	6.4	6.3	4.7	1.9	3.5	16.1	7.2
	14	0.8	0.9	7.8	5.4	7.3	14.2	7.6	5.9	10.9	11.2	5.6	6.8	6.9	3.8	1.9	3.2	16.6	7.4
R	15	0.9	1.1	7.1	4.7	7.1	14.6	7.6	6.8	12.9	10.1	6.0	5.6	6.8	3.3	1.9	3.4	16.6	7.4
	16	1.0	0.9	5.0	4.8	6.7	16.5	5.8	7.1	13.2	11.7	6.4	7.9	5.5	4.3	1.1	2.4	16.8	7.5
	17	1.3	1.4	6.1	3.1	6.7	14.0	7.0	8.4	15.4	12.9	6.4	6.5	5.0	1.9	1.9	2.2	16.5	7.4
	18	0.8	0.9	6.9	5.4	7.0	17.3	7.8	8.6	12.1	12.4	5.9	4.7	3.7	2.4	1.4	2.7	15.8	7.1
	19	0.6	1.1	7.1	5.9	9.2	20.7	9.2	11.5	12.0	8.1	3.4	4.7	3.2	1.8	0.3	1.1	14.4	6.4
	20	1.7	2.5	8.9	6.7	10.6	22.0	8.0	10.4	10.2	8.4	4.4	2.2	2.0	1.4	0.3	0.3	13.0	5.8
	21	3.3	3.1	11.5	7.9	11.2	20.2	8.7	9.0	8.8	8.1	2.7	2.5	1.1	0.9	0.8	0.3	12.1	5.4
	22	3.3	2.8	15.9	10.1	11.5	17.6	7.8	8.2	9.8	4.2	3.1	2.5	1.7	0.3	0.5	0.8	11.4	5.1
	23	5.9	3.9	16.9	8.5	9.6	17.2	7.3	7.2	7.9	8.1	1.7	0.8	3.0	0.9	0.5	0.7	11.0	4.9
	24	5.6	4.4	16.1	11.5	10.4	18.2	7.0	6.2	7.0	5.9	2.3	2.1	1.4	0.8	0.3	0.6	10.7	4.8
ALL HOURS		5.0	3.6	13.8	8.0	8.5	15.8	6.6	6.8	9.0	7.6	3.9	3.6	3.5	2.0	0.8	1.5	12.7	5.7

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 91

Percentage Frequency Summary for Wind Speed

JEFFERSON COUNTY - WHITEHALL FAA AIRPORT (SUMMER)

01/01/48 - 12/31/54

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	7.1	4.7	22.1	13.4	14.2	19.1	5.6	3.9	4.4	3.0	0.5	1.1	0.7	0.2	0.0	0.3	8.5	3.8
	2	8.5	7.6	22.7	13.2	14.6	17.2	4.0	3.3	3.3	2.8	0.9	0.9	0.5	0.2	0.0	0.2	7.8	3.5
	3	8.6	7.8	27.8	13.2	14.1	13.8	4.4	3.6	2.6	1.9	0.5	0.9	0.2	0.5	0.0	0.2	7.4	3.3
	4	10.6	8.3	28.1	14.4	11.2	12.8	3.6	3.5	3.6	2.8	0.6	0.3	0.0	0.2	0.0	0.0	7.0	3.1
	5	14.0	8.1	26.8	12.1	10.4	15.8	3.7	2.2	3.6	1.3	1.1	0.3	0.2	0.3	0.0	0.2	6.7	3.0
	6	14.3	7.8	30.1	12.7	11.3	12.0	3.1	3.0	1.9	1.4	0.9	0.5	0.7	0.3	0.0	0.2	6.5	2.9
	7	17.4	11.6	26.9	10.9	9.7	10.9	2.0	2.9	2.2	2.6	0.6	1.1	0.8	0.5	0.0	0.0	6.4	2.9
	8	13.5	7.5	25.6	10.3	11.2	14.3	3.2	3.1	3.4	2.3	1.7	1.2	1.6	0.7	0.2	0.3	7.7	3.5
H	9	4.7	3.1	20.0	13.8	11.8	21.1	5.9	4.0	5.6	3.9	1.3	1.9	1.0	1.2	0.6	0.2	9.8	4.4
	10	4.6	2.5	17.2	12.7	13.8	17.2	5.9	4.3	7.5	4.5	1.9	2.3	3.3	1.2	0.2	0.8	10.8	4.8
O	11	4.0	2.9	16.0	9.5	13.7	18.0	5.7	3.7	7.9	4.2	4.0	2.8	4.0	1.7	1.0	0.8	11.8	5.3
	12	3.6	2.0	13.0	10.4	13.2	15.7	6.5	7.4	6.5	5.9	4.0	3.4	3.4	2.0	0.8	1.9	12.7	5.7
U	13	1.3	1.5	10.3	10.0	13.4	18.2	5.6	6.2	8.5	8.2	3.4	3.6	4.8	1.2	1.2	2.6	13.8	6.2
	14	0.9	1.0	8.7	5.1	10.6	23.1	5.9	6.4	10.9	8.7	3.6	4.7	4.1	1.7	1.7	3.1	14.9	6.7
R	15	0.6	0.6	8.7	7.0	8.6	18.5	6.7	8.6	13.7	8.4	4.0	5.0	5.0	2.0	1.2	1.6	14.9	6.7
	16	0.6	0.3	4.8	7.1	9.0	19.1	7.8	10.4	11.8	8.7	4.0	6.1	5.0	2.6	1.1	1.6	15.6	7.0
	17	1.5	0.7	6.5	5.4	9.5	20.4	7.9	8.2	10.2	11.0	4.3	4.2	4.3	2.3	0.6	2.9	15.1	6.7
	18	1.1	0.6	7.1	4.8	8.1	19.9	7.5	9.1	14.0	10.3	4.3	4.5	3.3	2.0	1.2	2.3	15.3	6.8
	19	1.7	1.1	5.9	6.8	8.5	24.3	8.1	9.2	12.0	8.9	4.0	3.1	2.8	1.9	0.9	0.8	14.1	6.3
	20	2.3	2.0	7.8	8.4	11.8	25.5	7.6	10.6	10.6	5.1	2.5	2.6	1.9	1.1	0.0	0.2	12.4	5.5
	21	2.7	2.8	10.0	11.4	13.2	25.9	8.4	7.6	6.5	6.4	1.6	1.1	1.2	0.8	0.0	0.5	11.3	5.0
	22	3.1	1.6	14.6	11.5	14.6	25.0	8.2	8.4	7.2	1.9	1.4	0.8	0.8	0.3	0.3	0.3	10.4	4.6
	23	4.2	3.9	18.5	11.6	14.0	23.8	5.3	6.8	5.2	3.4	0.8	0.9	0.5	0.6	0.2	0.3	9.5	4.3
	24	6.2	2.6	21.3	11.8	16.6	20.4	6.4	4.8	4.5	2.4	1.1	1.6	0.2	0.3	0.0	0.0	8.9	4.0
ALL HOURS		5.7	3.9	16.7	10.3	11.9	18.8	5.8	5.9	7.0	5.0	2.2	2.3	2.1	1.1	0.5	0.8	10.8	4.8

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 92

Percentage Frequency Summary for Wind Speed

JEFFERSON COUNTY - WHITEHALL FAA AIRPORT (AUTUMN)

01/01/48 - 12/31/54

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	9.1	6.2	21.9	11.6	10.4	13.4	3.0	3.6	5.2	4.1	2.5	2.7	2.2	1.4	1.1	1.6	10.0	4.5
	2	10.0	4.6	23.7	11.4	9.1	13.7	3.6	3.5	4.9	4.5	2.8	2.2	2.2	1.6	0.8	1.5	9.8	4.4
	3	9.1	5.8	23.1	11.8	9.1	12.3	3.7	4.4	5.7	3.6	2.0	1.9	2.8	1.9	0.6	2.3	10.1	4.5
	4	11.2	5.4	25.9	11.2	9.5	8.3	5.7	3.3	4.7	3.0	3.6	1.6	2.1	1.4	0.8	2.6	9.6	4.3
	5	10.8	5.4	27.2	10.9	7.5	10.2	1.9	3.0	6.0	3.9	2.7	2.4	3.5	1.9	1.1	1.8	10.0	4.5
	6	10.8	6.2	25.6	11.5	8.5	10.5	3.4	2.8	4.1	5.1	2.0	2.7	1.1	2.0	0.3	3.4	9.8	4.4
	7	13.9	5.8	24.7	10.7	6.6	9.5	4.3	3.8	4.4	4.9	2.2	2.5	1.7	1.3	0.3	3.5	9.6	4.3
	8	14.3	6.0	24.7	10.2	6.9	8.7	3.1	3.6	4.4	5.3	3.6	1.3	2.7	2.4	0.5	2.4	9.7	4.3
H	9	8.8	5.3	24.0	9.4	8.8	11.9	3.9	3.9	5.2	3.9	1.5	3.0	4.2	2.5	1.3	2.3	10.6	4.8
	10	6.1	3.4	19.3	9.6	9.3	14.5	4.2	3.6	5.8	5.0	3.3	4.9	3.6	3.0	1.1	3.3	12.4	5.5
O	11	5.0	2.2	14.6	7.7	8.8	13.7	5.2	6.0	5.8	6.6	4.1	4.9	6.9	3.3	1.7	3.6	14.2	6.4
	12	2.4	2.5	12.6	9.2	8.5	9.7	5.8	6.1	7.5	8.3	4.4	5.5	6.0	4.7	2.2	4.6	15.4	6.9
U	13	2.8	2.1	10.7	8.3	7.4	12.0	3.9	4.9	6.9	9.3	7.0	6.0	7.2	4.6	1.9	5.2	16.2	7.2
	14	2.4	1.4	11.9	6.8	7.1	11.5	3.9	6.6	10.3	8.8	6.3	5.8	7.5	3.6	1.8	4.5	16.2	7.2
R	15	2.8	1.7	9.9	6.8	8.2	11.6	6.3	6.6	9.4	8.3	7.5	5.8	6.9	4.1	0.6	3.5	15.8	7.1
	16	1.7	1.6	10.2	7.5	8.0	13.4	6.6	6.0	12.9	11.5	4.1	5.5	4.1	3.0	1.2	2.9	15.2	6.8
	17	2.7	0.9	8.8	7.4	8.2	17.3	7.5	11.4	10.7	8.3	4.4	3.8	3.5	2.2	0.5	2.6	14.3	6.4
	18	1.9	2.5	9.8	7.4	9.9	22.4	8.1	8.5	10.2	6.9	3.9	2.5	2.2	1.1	0.7	2.1	13.3	5.9
	19	3.8	2.4	10.7	9.8	11.2	21.3	8.1	7.1	10.4	5.2	2.8	1.4	1.9	1.4	0.5	2.1	12.4	5.5
	20	3.1	3.6	14.3	9.3	12.6	17.6	8.5	8.5	9.0	3.3	1.9	2.3	2.5	1.4	0.5	1.8	11.9	5.3
	21	6.1	2.6	17.3	9.5	8.5	20.7	8.8	4.5	6.1	6.0	2.3	1.9	2.5	1.0	0.3	2.0	11.2	5.0
	22	6.3	3.9	18.5	12.1	7.9	18.5	6.6	5.2	6.6	3.5	1.9	2.5	1.9	2.2	0.6	1.9	11.0	4.9
	23	9.0	4.1	17.5	11.7	9.8	14.6	6.0	5.9	6.4	3.8	3.6	1.3	2.5	1.7	0.5	1.8	10.7	4.8
	24	8.7	3.5	22.1	12.3	8.0	15.3	3.3	5.2	5.5	5.4	2.5	2.2	2.4	1.0	0.6	2.1	10.4	4.6
ALL HOURS		6.8	3.7	17.9	9.7	8.7	13.9	5.2	5.3	7.0	5.8	3.4	3.2	3.5	2.3	0.9	2.7	12.1	5.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 93

Annual Wind Rose Distribution

JEFFERSON COUNTY - WHITEHALL FAA AIRPORT

01/01/48 - 12/31/54

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4
3.4- 5.4	0.5	0.1	0.3	0.1	0.2	0.0	0.2	0.1	0.5	0.0	0.4	0.1	0.4	0.1	0.4	0.1	3.5	1.5- 2.4
5.6- 7.6	1.5	0.6	1.3	0.4	0.8	0.2	0.9	0.3	1.3	0.5	1.7	0.6	1.7	0.8	2.0	0.6	15.2	2.5- 3.4
7.8- 9.8	0.7	0.4	0.8	0.2	0.4	0.1	0.3	0.2	0.8	0.3	1.0	0.5	0.8	0.6	1.2	0.3	8.6	3.5- 4.4
10.1-12.1	0.6	0.4	1.0	0.3	0.3	0.1	0.3	0.2	0.8	0.4	0.9	0.5	0.9	0.6	1.0	0.4	8.7	4.5- 5.4
12.3-14.3	0.8	0.9	1.8	0.6	0.4	0.1	0.3	0.3	1.3	1.1	1.8	0.9	1.5	1.1	1.1	0.5	14.5	5.5- 6.4
14.5-16.6	0.2	0.4	0.7	0.2	0.1	0.0	0.1	0.1	0.5	0.6	0.9	0.3	0.5	0.4	0.3	0.1	5.4	6.5- 7.4
16.8-18.8	0.2	0.4	0.8	0.2	0.1	0.0	0.0	0.1	0.5	0.8	1.0	0.3	0.5	0.5	0.3	0.1	5.8	7.5- 8.4
19.0-21.0	0.1	0.6	0.8	0.2	0.1	0.0	0.0	0.1	0.7	1.4	1.6	0.4	0.5	0.7	0.3	0.1	7.6	8.5- 9.4
21.3-23.3	0.1	0.4	0.5	0.2	0.0	0.0	0.0	0.1	0.6	1.6	1.4	0.3	0.4	0.5	0.2	0.0	6.3	9.5-10.4
23.5-25.5	0.0	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.3	1.2	0.9	0.2	0.2	0.2	0.1	0.0	3.6	10.5-11.4
25.7-27.7	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.4	1.2	1.0	0.2	0.2	0.2	0.1	0.0	3.6	11.5-12.4
28.0-30.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.4	1.5	1.1	0.2	0.1	0.2	0.1	0.0	3.8	12.5-13.4
30.2-32.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	0.8	0.1	0.1	0.1	0.0	0.0	2.6	13.5-14.4
32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.4	0.0	0.0	0.1	0.0	0.0	1.1	14.5-15.4
34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.4	0.0	0.0	0.1	0.0	0.0	1.2	15.5-16.4
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.4	16.5-17.4
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.4	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.3	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.3	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.4	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
CALM																	5.5	CALM
TOTAL	4.9	4.7	8.6	2.6	2.4	0.8	2.1	1.5	8.7	14.1	16.0	4.8	8.0	6.2	7.0	2.2	100.1	TOTAL
AV SPD (MPH)	8.1	13.2	11.6	11.6	7.2	7.4	6.3	10.3	13.9	22.6	17.4	13.4	11.0	13.6	8.7	8.3	11.5	AV SPD (MPH)
AV SPD (M/S)	3.6	5.9	5.2	5.2	3.2	3.3	2.8	4.6	6.2	10.1	7.8	6.0	4.9	6.1	3.9	3.7	5.2	AV SPD (M/S)

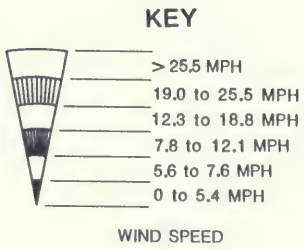
SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

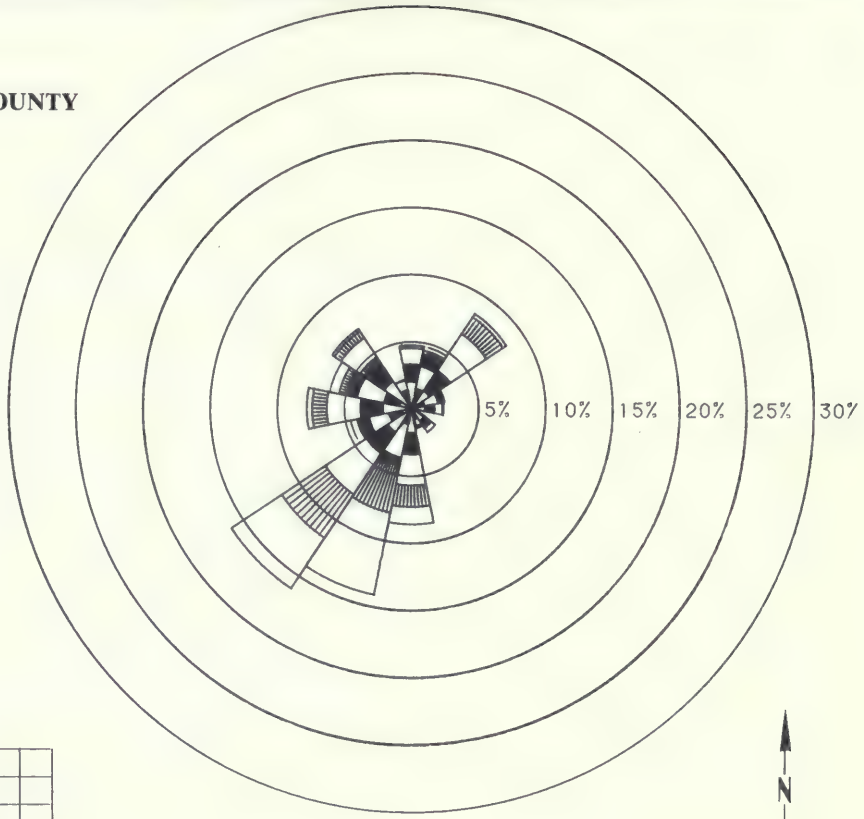
Figure IV - 10

Annual Wind Rose

WHITEHALL FAA AIRPORT — JEFFERSON COUNTY

(1984 - 1954)





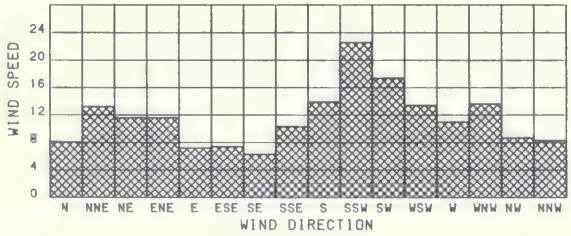


Table IV - 94

Coefficients of Weibull Distribution

JEFFERSON COUNTY - WHITEHALL FAA AIRPORT

01/01/48 - 12/31/54

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	9.2990	1.5450
FEBRUARY	8.4560	1.7370
MARCH	7.1330	1.8280
APRIL	7.1640	1.9410
MAY	6.4880	1.8700
JUNE	6.4630	1.9780
JULY	6.2620	1.8420
AUGUST	5.7630	1.7360
SEPTEMBER	5.9020	1.8540
OCTOBER	6.6140	1.6180
NOVEMBER	7.8100	1.7390
DECEMBER	8.9070	1.6910
YEAR	7.2800	1.6720

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

RONAN NINEPIPES
LAKE COUNTY

The Ronan Ninepipes monitoring site is located 5 miles south of Ronan at 47 27 35 N and 114 07 59 W (Site No. 66 on Map II-1). Elevation at the site is 3,020 feet. The site was established by the Montana Air Quality Bureau as part of the Flathead River Basin Environmental Impact Study.

Wind data from December 11, 1980 through February 26, 1982, were available for analysis. The data set contains hourly averages for wind speed and wind direction. These data were recorded by a data acquisition system that scanned each parameter several times per minute. Measurements were made by a Climatronics electronic anemometer and wind vane on a 10-meter tower.

The period of monitoring was long enough to adequately represent the wind resource at this location. Data recovery was good, ranging from 50.0 percent in September to 100.0 percent in February and May. Overall data recovery for the monitoring period was 91.8 percent. The site is located in the Flathead Valley, and the data are representative of a large area from Ronan to Saint Ignatius, with the exception of areas on the eastern side of the valley near the openings of canyons.

Average annual wind speed was 4.5 miles per hour. Average monthly wind speeds ranged from 3.3 miles per hour in November to 6.2 miles per hour in April.

Average monthly wind power varied from 6.2 watts/m^2 in August to 31.4 watts/m^2 in February and April. Average annual wind power was 17.0 watts/m^2.

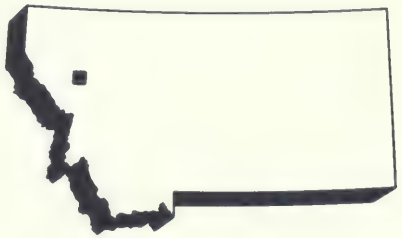


Table IV - 95

Monthly Wind Speed Distribution

LAKE COUNTY - RONAN NINEPIPES

12/11/80 - 02/26/82

WIND SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	WIND SPEED (M/SEC)
CALM	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.5	0.2	CALM
0.1-1.0	11.1	3.4	3.0	0.6	3.2	2.0	3.4	3.1	2.2	4.0	5.5	6.1	4.6	0.1- 0.4
1.1-2.0	16.5	12.5	13.7	7.1	13.2	9.7	12.9	14.2	11.1	17.2	22.0	19.7	14.5	0.5- 0.9
2.1-3.0	27.4	21.1	26.9	15.6	24.1	18.8	28.8	31.0	24.4	29.1	28.5	21.8	24.5	1.0- 1.3
3.1-4.0	8.3	14.4	22.8	11.6	18.8	14.8	13.1	13.6	19.4	14.2	15.2	14.1	14.4	1.4- 1.8
4.1-5.0	11.9	10.8	13.3	12.3	16.7	13.6	13.9	16.0	18.9	10.0	13.0	11.5	13.0	1.9- 2.2
5.1-6.0	4.3	6.4	5.2	9.1	7.0	8.9	4.6	5.5	6.4	4.5	4.9	4.6	5.8	2.3- 2.7
6.1-7.0	4.9	5.1	4.2	9.5	5.8	10.2	5.9	7.2	8.9	8.1	3.2	4.4	6.0	2.8- 3.1
7.1-8.0	1.7	3.4	3.8	5.8	2.8	6.3	3.0	3.4	3.6	2.1	2.5	3.2	3.3	3.2- 3.6
8.1-9.0	2.4	4.0	3.0	6.5	3.0	6.5	3.1	2.7	2.8	4.2	1.4	1.9	3.3	3.7- 4.0
9.1-10.0	1.5	2.7	1.3	4.7	1.7	4.1	3.6	1.1	0.6	1.3	0.9	1.4	2.1	4.1- 4.5
10.1-11.0	1.9	2.9	0.7	6.4	1.1	2.6	3.0	1.3	1.1	2.3	1.0	1.4	2.2	4.6- 4.9
11.1-12.0	1.3	1.9	0.3	1.7	0.7	1.1	0.9	0.0	0.0	0.9	0.6	1.4	1.0	5.0- 5.4
12.1-13.0	1.1	2.5	0.5	2.4	0.8	0.6	0.5	0.6	0.0	0.8	0.4	1.9	1.2	5.5- 5.8
13.1-14.0	0.9	1.6	0.5	1.7	0.5	0.4	0.9	0.0	0.3	0.0	0.0	0.9	0.8	5.9- 6.3
14.1-15.0	1.2	1.9	0.4	1.3	0.4	0.3	0.1	0.3	0.3	0.6	0.3	1.3	0.8	6.4- 6.7
15.1-16.0	0.7	1.2	0.3	1.1	0.0	0.1	0.4	0.0	0.0	0.2	0.1	1.2	0.6	6.8- 7.2
16.1-17.0	0.6	0.7	0.0	0.7	0.1	0.0	0.7	0.0	0.0	0.2	0.1	0.8	0.4	7.3- 7.6
17.1-18.0	0.5	1.2	0.1	1.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	1.0	0.5	7.7- 8.0
18.1-19.0	0.2	0.8	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.2	8.1- 8.5
19.1-20.0	0.3	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.2	8.6- 8.9
20.1-25.0	0.7	0.6	0.0	0.4	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.3	0.3	9,0-11.2
25.1-30.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3-13.4
30.1-35.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5-15.6
35.1-40.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	4.2	5.4	3.8	6.2	4.1	4.9	4.5	3.8	4.0	4.0	3.3	4.4	4.5	
AVERAGE SPEED (M/SEC)	1.9	2.4	1.7	2.8	1.8	2.2	2.0	1.7	1.8	1.8	1.5	2.0	2.0	
AVERAGE WIND POWER (WATTS/M**2)	23.0	31.4	8.0	31.4	8.9	12.1	16.0	6.2	6.3	10.1	6.3	21.6	17.0	
PERCENT DATA RECOVERY	96.4	99.0	100.0	97.9	100.0	97.8	99.7	85.9	50.0	71.2	96.0	94.7	91.8	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 9759
PERCENTAGE DATA RECOVERY = 91.8

SOURCE: GEORESEARCH, INC.

HELENA NWS AIRPORT

LEWIS AND CLARK COUNTY

The Helena airport is located approximately 2 miles east of Helena at 46 36 21 N and 112 00 00 W (Site No. 71 on Map II-1). Elevation at the airport is 3,897 feet. Meteorological data have been collected at this site for many years by the National Weather Service.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the data set was split into two parts for analysis: January 1, 1948, through September 19, 1961; and September 20, 1961, through December 31, 1978. Only data from the more recent period were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Helena consists of summaries of observations made every third hour from September 20, 1961, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 6.1 meters. Due to the complex terrain, the site is representative only of a limited area in the Helena valley.

Average annual wind speed was 7.8 miles per hour. Average monthly wind speeds varied from 7.4 miles per hour in August through December to 9.4 miles per hour in April.

Average annual wind power was 69.0 watts/m². Average monthly wind power ranged from 50.0 watts/m² in August to 97.0 watts/m² in April.

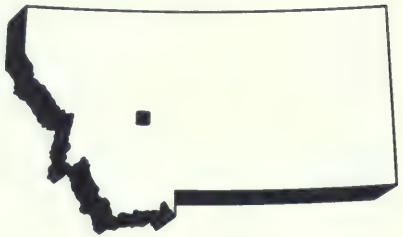


Table IV - 96

Monthly Wind Speed Distribution

LEWIS AND CLARK COUNTY - HELENA NWS AIRPORT

09/20/61 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	12.9	11.0	6.9	5.9	5.1	4.6	5.7	6.9	9.5	9.6	10.0	11.5	8.3	CALM (<0.5)
1.1- 3.1	5.4	4.8	3.2	2.9	2.1	1.9	2.3	2.2	2.9	4.3	5.2	5.4	3.6	0.5- 1.4
3.4- 5.4	24.1	26.5	21.2	18.5	19.1	21.9	25.3	25.8	26.4	27.7	28.1	27.0	24.3	1.5- 2.4 S
S 5.6- 7.6	18.2	18.2	19.1	19.0	21.9	23.8	25.5	24.3	22.1	21.0	20.3	19.3	21.1	2.5- 3.4 P
P 7.8- 9.8	11.3	11.3	14.0	15.6	17.2	16.1	16.7	18.1	14.5	13.2	12.4	11.0	14.3	3.5- 4.4 E
E 10.1-12.1	8.9	8.0	10.8	10.6	12.0	9.8	9.0	7.9	9.0	7.3	7.2	8.4	9.1	4.5- 5.4 E
E 12.3-14.3	5.6	5.3	6.6	7.4	6.9	6.8	4.9	4.9	5.5	4.5	4.9	5.0	5.7	5.5- 6.4 D
D 14.5-16.6	4.1	5.1	6.9	7.1	5.7	5.7	4.2	3.9	3.8	4.6	4.3	4.1	4.9	6.5- 7.4
16.8-18.8	3.7	4.2	4.7	5.5	3.9	4.4	3.2	3.0	2.9	3.4	3.0	3.5	3.8	7.5- 8.4 M
M 19.0-21.0	2.6	2.6	3.7	3.7	3.1	2.6	1.8	1.6	1.7	2.5	2.1	2.3	2.5	8.5- 9.4 E
I 21.3-23.3	1.6	1.5	1.6	2.1	1.6	1.4	0.7	0.6	1.1	1.3	1.0	1.4	1.3	9.5-10.4 T
L 23.5-25.5	0.6	0.7	0.6	0.8	0.6	0.5	0.4	0.3	0.3	0.4	0.6	0.5	0.5	10.5-11.4 E
E 25.7-27.7	0.2	0.4	0.3	0.5	0.5	0.2	0.2	0.2	0.3	0.2	0.4	0.2	0.3	11.5-12.4 R
S 28.0-30.0	0.5	0.2	0.2	0.3	0.1	0.1	0.0	0.1	0.0	0.0	0.2	0.2	0.2	12.5-13.4 S
/ 30.2-32.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	13.5-14.4 /
H 32.4-34.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5-15.4 S
O 34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	7.6	7.6	8.7	9.4	8.9	8.5	7.6	7.4	7.4	7.4	7.4	7.4	7.8	
AVERAGE SPEED (M/SEC)	3.4	3.4	3.9	4.2	4.0	3.8	3.4	3.3	3.3	3.3	3.3	3.3	3.5	
AVERAGE WIND POWER (WATTS/M**2)	77.0	75.0	85.0	97.0	79.0	70.0	52.0	50.0	53.0	58.0	65.0	67.0	69.0	

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

SIEBEN RANCH 1
LEWIS AND CLARK COUNTY

The Sieben Ranch 1 site is located about 25 miles northwest of Helena at 46 55 00 N and 112 13 00 W (Site No. 154 on Map II-1). Elevation at the site is about 5,600 feet. (The location and elevation are given incorrectly in earlier BPA publications.) This monitoring site was part of the Wind Regional Energy Assessment Program run by Oregon State University for Bonneville Power Administration.

The site is in an area of numerous well exposed rolling hilltops and ridges. The hilltops are smooth and the slopes are moderate to steep. The site is representative of a large area. Access to the area is excellent, with an all-weather state road to the south and west and Interstate Highway 15 to the east. Access to the site itself is by dirt road. Winter access is sometimes hampered by drifting snow.

Most of the land in the area is privately owned, though there are sections of BLM and state property. Electrical service in the area is provided by the Montana Power Company. A Montana Power 115 kV line runs within 7 miles of the site, but nearest substation is outside of Helena. The nearest commercial airport is located at Helena.

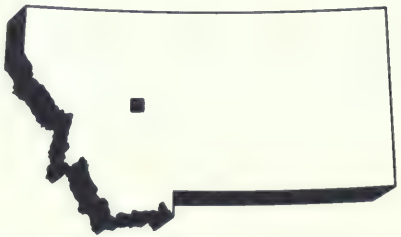
Collection of wind data began February 18, 1984 and ran through July 28, 1984. This period was too brief to serve as the basis for long term predictions, but the data were sufficiently encouraging to warrant inclusion in the *Atlas*. The anemometer height was 35 feet.

Data recovery, made with a data logger, was excellent, ranging from 88.0 percent in February to 99.9 percent in June. The overall data recovery was 97.0 percent.

Average monthly wind speeds ranged from 14.4 miles per hour in July to 20.4 miles per hour in February. Average wind speed for the five-month period was 16.7 miles per hour. The winds blew from the west nearly half the time. It is not clear whether this preponderance of wind from one direction is due to the effects of local terrain or to a malfunctioning wind vane.

Average monthly wind power ranged from 225.9 watts/m^2 in July up to 627.4 watts/m^2 in February.

Because of the short monitoring period, only the monthly wind speed distribution is reported here, even though Sieben Ranch appears to be a high potential site.



Monthly Wind Speed Distribution

LEWIS AND CLARK COUNTY - SIEBEN 1

02/18/84 - 07/28/84

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	SPEED (MPH)
CALM	0.0	0.4	1.4	1.7	0.4	0.6	1.8	0.0	0.0	0.0	0.0	0.0	1.1	CALM
0.1-1.0	0.0	0.8	1.6	2.1	1.5	0.8	1.5	0.0	0.0	0.0	0.0	0.0	1.5	0.1- 0.4
1.1-2.0	0.0	2.1	1.1	3.6	1.2	1.1	1.7	0.0	0.0	0.0	0.0	0.0	1.8	0.5- 0.9
2.1-3.0	0.0	2.1	4.1	3.1	1.3	1.7	1.5	0.0	0.0	0.0	0.0	0.0	2.3	1.0- 1.3
3.1-4.0	0.0	3.7	3.4	4.1	2.7	2.1	3.2	0.0	0.0	0.0	0.0	0.0	3.1	1.4- 1.8
4.1-5.0	0.0	2.5	3.4	4.9	2.2	3.6	2.4	0.0	0.0	0.0	0.0	0.0	3.3	1.9- 2.2
5.1-6.0	0.0	0.8	2.0	3.1	1.9	4.7	3.6	0.0	0.0	0.0	0.0	0.0	2.9	2.3- 2.7
6.1-7.0	0.0	0.8	3.5	4.4	3.3	4.9	5.0	0.0	0.0	0.0	0.0	0.0	4.0	2.8- 3.1
7.1-8.0	0.0	2.1	2.8	4.4	3.3	4.0	4.1	0.0	0.0	0.0	0.0	0.0	3.6	3.2- 3.6
8.1-9.0	0.0	2.1	4.5	5.2	3.9	4.0	3.8	0.0	0.0	0.0	0.0	0.0	4.1	3.7- 4.0
9.1-10.0	0.0	2.5	3.4	3.0	2.1	3.9	5.3	0.0	0.0	0.0	0.0	0.0	3.5	4.1- 4.5
10.1-11.0	0.0	1.6	4.5	4.7	3.3	3.2	5.0	0.0	0.0	0.0	0.0	0.0	4.0	4.6- 4.9
11.1-12.0	0.0	2.9	3.5	3.7	2.4	6.0	5.0	0.0	0.0	0.0	0.0	0.0	4.1	5.0- 5.4
12.1-13.0	0.0	4.5	3.2	3.7	1.8	4.9	4.8	0.0	0.0	0.0	0.0	0.0	3.8	5.5- 5.8
13.1-14.0	0.0	0.8	3.4	3.6	3.4	4.3	4.2	0.0	0.0	0.0	0.0	0.0	3.6	5.9- 6.3
14.1-15.0	0.0	4.1	4.0	5.6	3.1	4.3	5.0	0.0	0.0	0.0	0.0	0.0	4.4	6.4- 6.7
15.1-16.0	0.0	2.1	3.5	3.3	2.4	3.8	2.7	0.0	0.0	0.0	0.0	0.0	3.1	6.8- 7.2
16.1-17.0	0.0	3.7	3.8	3.1	4.0	3.2	4.4	0.0	0.0	0.0	0.0	0.0	3.7	7.3- 7.6
17.1-18.0	0.0	4.1	3.8	2.9	3.3	3.1	4.8	0.0	0.0	0.0	0.0	0.0	3.6	7.7- 8.0
18.1-19.0	0.0	3.7	2.7	2.0	1.8	3.6	5.4	0.0	0.0	0.0	0.0	0.0	3.1	8.1- 8.5
19.1-20.0	0.0	4.1	3.0	2.3	3.0	2.4	4.1	0.0	0.0	0.0	0.0	0.0	3.0	8.6- 8.9
20.1-25.0	0.0	13.6	12.1	9.0	16.3	12.4	12.4	0.0	0.0	0.0	0.0	0.0	12.5	9.0-11.2
25.1-30.0	0.0	17.7	9.2	7.6	14.4	9.5	5.0	0.0	0.0	0.0	0.0	0.0	9.7	11.3-13.4
30.1-35.0	0.0	9.1	6.9	4.9	9.2	4.5	1.5	0.0	0.0	0.0	0.0	0.0	5.6	13.5-15.6
35.1-40.0	0.0	5.8	2.7	3.1	5.2	1.8	1.1	0.0	0.0	0.0	0.0	0.0	3.0	15.7-17.9
>40.0	0.0	2.5	2.4	0.7	2.7	1.8	0.6	0.0	0.0	0.0	0.0	0.0	1.7	>17.9
AVERAGE SPEED (MPH)	ND	20.4	16.9	14.7	19.7	16.3	14.4	ND	ND	ND	ND	ND	16.7	
AVERAGE SPEED (M/SEC)	ND	9.1	7.6	6.6	8.8	7.3	6.5	ND	ND	ND	ND	ND	7.4	
AVERAGE WIND POWER (WATTS/M**2)	ND	627.4	463.6	328.7	561.0	361.1	225.9	ND	ND	ND	ND	ND	404.3	
PERCENT DATA RECOVERY	0.0	88.0	95.2	97.1	98.4	99.9	98.4	0.0	0.0	0.0	0.0	0.0	97.0	

ANEMOMETER HEIGHT = 11 METERS = 35 FEET
NUMBER OF OBSERVATIONS = 3703
PERCENTAGE DATA RECOVERY = 97.0

SOURCE: GEORESEARCH, INC.

WHITLASH
LIBERTY COUNTY

The Whitlash site is located four miles south of Whitlash and about twenty-eight miles north-northwest of Chester at 48 51 36 N and 111 14 46 W (Site No. 156 on Map II-1). Elevation at the site is 4,300 feet. This monitoring site is part of the wind monitoring program of the Montana Department of Natural Resources and Conservation.

The site is atop a drainage divide in a rolling grassland area near the Sweet Grass Hills. It has excellent exposure to winds from all directions. The site is indicative of the potential of a drainage divide that runs approximately east and west and is several miles long. The site is right next to a county road, but 28 miles from a paved road. Winter access sometimes is hampered by drifting snow and severe weather conditions.

The site is located in a sparsely populated area near the Canadian border. Most of the land in the area is privately owned. Electrical service in the area is provided by the Marias Electric Cooperative. One 115 kV line runs along the highway 28 miles south from Havre to Cut Bank. There is no commercial airport nearby.

Wind data was collected from November 18, 1983 to July 24, 1985. A Met One anemometer and a Campbell Scientific datalogger were used. The anemometer height was 33 feet.

Data recovery was poor to excellent, ranging from 0.0 percent in October to 99.9 percent in August. Overall data recovery was 76.6 percent.

Average monthly wind speeds ranged from 11.7 miles per hour in March to 15.5 miles per hour in September. The March figure may be inaccurate because of the poor data recovery that month. Average annual wind speed was 13.6 miles per hour.

Average monthly wind power ranged from 129.4 watts/m^2 in July up to 465.0 watts/m^2 in January.

Average wind speed did not vary much between seasons. Average seasonal speeds were 12.7 miles per hour in the summer, 13.2 miles per hour in the autumn, 14.2 miles per hour in the winter, and 14.1 miles per hour in the spring. In the winter, the highest wind speed occurred in mid-afternoon. In the spring, highest winds happened in the late afternoon and early evening. High winds in the summer were somewhat later still in the early evening. In the fall, the highest winds came in the early afternoon. Diurnal range of average wind speeds was greatest in the summer and somewhat less in the autumn and spring. The range was smallest in the winter.

The most common wind direction was from the north. Winds blew about four to nine percent of the time from most other directions; winds from the northeast through east-southeast were fairly uncommon. By direction, average wind speeds ranged from 20.4 miles per hour from the west to 5.6 miles per hour from the east.

Table IV - 98

Monthly Wind Speed Distribution

LIBERTY COUNTY - WHITLASH

11/18/83 - 07/24/85

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	1.4	0.0	1.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.3	CALM
0.1-1.0	0.8	0.1	0.6	0.1	0.0	0.2	0.2	0.0	0.2	0.0	0.9	1.1	0.4	0.1- 0.4
1.1-2.0	1.5	1.3	2.6	0.9	0.7	0.8	0.8	0.5	0.5	0.0	1.9	1.9	1.2	0.5- 0.9 S
S 2.1-3.0	2.5	1.5	3.5	1.4	0.7	2.0	2.2	1.9	2.8	0.0	2.5	2.6	2.0	1.0- 1.3 P
P 3.1-4.0	5.3	4.6	5.0	3.2	2.4	4.2	3.9	4.3	4.2	0.0	5.1	3.6	4.1	1.4- 1.8 E
E 4.1-5.0	5.0	3.6	4.4	3.9	3.8	4.1	4.0	3.9	3.4	0.0	4.4	4.2	4.1	1.9- 2.2 E
E 5.1-6.0	5.1	7.1	8.3	4.9	6.1	5.1	6.0	6.3	5.5	0.0	8.2	4.8	6.0	2.3- 2.7 D
D 6.1-7.0	3.7	5.5	5.7	3.5	5.3	5.1	5.8	5.8	4.4	0.0	6.0	5.4	5.1	2.8- 3.1
7.1-8.0	5.5	6.0	6.0	4.8	6.0	7.0	7.7	7.7	5.1	0.0	9.1	6.5	6.5	3.2- 3.6 M
M 8.1-9.0	3.5	4.3	5.1	4.1	4.7	4.4	6.1	5.8	5.1	0.0	7.6	4.6	5.0	3.7- 4.0 E
I 9.1-10.0	4.5	6.4	6.6	6.4	5.5	6.3	6.9	7.8	6.2	0.0	6.8	5.5	6.2	4.1- 4.5 T
L 10.1-11.0	5.3	4.6	4.4	3.0	5.0	4.5	6.3	5.7	4.9	0.0	5.3	6.3	5.0	4.6- 4.9 E
E 11.1-12.0	4.9	6.3	5.5	4.4	5.9	5.6	6.9	4.7	4.1	0.0	5.5	6.9	5.6	5.0- 5.4 R
S 12.1-13.0	3.0	4.3	3.4	4.1	6.0	4.3	4.7	5.0	2.8	0.0	4.3	4.7	4.4	5.5- 5.8 S
/ 13.1-14.0	3.8	5.7	5.5	4.8	4.1	4.9	6.8	4.7	3.7	0.0	5.0	5.1	5.0	5.9- 6.3 /
H 14.1-15.0	3.6	3.7	3.4	3.9	3.8	3.3	3.8	5.5	2.6	0.0	2.2	3.7	3.6	6.4- 6.7 S
O 15.1-16.0	2.6	3.0	3.8	3.1	3.4	3.8	4.1	3.2	3.5	0.0	2.1	3.5	3.3	6.8- 7.2 E
U 16.1-17.0	2.8	4.1	3.2	3.3	3.9	4.9	4.4	4.8	2.3	0.0	2.6	2.3	3.6	7.3- 7.6 C
R 17.1-18.0	2.3	2.4	2.3	3.2	2.4	4.0	2.7	2.3	2.5	0.0	1.5	2.4	2.6	7.7- 8.0 O
18.1-19.0	2.6	3.3	3.5	4.2	3.8	4.3	4.9	3.2	3.5	0.0	2.5	2.0	3.5	8.1- 8.5 N
19.1-20.0	1.8	1.7	2.3	3.7	3.8	2.9	3.5	1.5	2.3	0.0	0.8	1.3	2.5	8.6- 8.9 D
20.1-25.0	8.4	10.3	6.1	17.1	11.1	10.6	5.5	10.0	12.0	0.0	6.9	9.4	9.8	9.0-11.2
25.1-30.0	8.3	5.4	4.5	6.5	6.7	5.8	2.2	3.2	9.3	0.0	4.6	4.9	5.5	11.3-13.4
30.1-35.0	5.9	2.9	2.5	3.8	4.1	1.0	0.5	0.9	4.4	0.0	2.7	3.4	2.9	13.5-15.6
35.1-40.0	3.0	0.6	0.0	1.4	0.7	0.4	0.0	0.4	3.0	0.0	1.2	2.0	1.1	15.7-17.9
>40.0	2.8	0.9	0.0	0.1	0.0	0.4	0.0	0.8	1.6	0.0	0.0	1.5	0.7	>17.9
AVERAGE SPEED (MPH)	15.3	13.6	11.7	15.3	14.4	13.4	11.9	12.7	15.5	ND	11.9	13.7	13.6	
AVERAGE SPEED (M/SEC)	6.8	6.1	5.2	6.8	6.4	6.0	5.3	5.7	6.9	ND	5.3	6.1	6.1	
AVERAGE WIND POWER (WATTS/M**2)	465.0	272.6	173.9	313.8	261.1	208.6	129.4	188.0	377.3	ND	196.6	312.2	259.6	
PERCENT DATA RECOVERY	73.7	72.5	46.0	72.7	99.5	99.8	98.5	99.9	78.8	0.0	94.2	66.5	76.6	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 11310
PERCENTAGE DATA RECOVERY = 76.6

SOURCE: GEORESEARCH, INC.

Table IV - 99

Percentage Frequency Summary for Wind Speed

LIBERTY COUNTY - WHITLASH

(WINTER)

11/18/83 - 07/24/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	1.6	7.8	10.9	10.9	10.9	11.6	8.5	6.2	4.7	3.9	8.5	7.0	4.7	2.3	0.8	14.0	6.3
	2	1.6	0.8	7.0	12.4	13.2	9.3	6.2	10.1	5.4	5.4	5.4	10.9	5.4	4.7	2.3	0.0	13.8	6.2
	3	1.6	0.0	8.5	8.5	18.6	7.0	7.8	9.3	7.8	4.7	5.4	10.9	3.1	5.4	0.8	0.8	13.4	6.0
	4	1.6	0.0	10.9	11.6	10.9	9.3	14.0	6.2	3.1	8.5	2.3	10.1	3.9	6.2	0.0	1.6	13.4	6.0
	5	0.0	3.1	7.0	15.5	10.9	7.8	10.1	7.0	5.4	2.3	9.3	11.6	3.1	3.1	1.6	2.3	13.7	6.1
	6	0.0	2.3	5.4	10.9	10.1	11.6	10.9	5.4	7.8	5.4	10.9	7.8	3.1	3.1	1.6	3.9	14.6	6.5
	7	0.0	3.9	7.0	12.4	11.6	6.2	10.1	11.6	8.5	2.3	3.1	11.6	2.3	3.9	0.8	4.7	14.2	6.4
	8	0.0	2.3	4.7	14.0	11.6	9.3	11.6	10.1	5.4	3.1	7.8	5.4	5.4	5.4	0.8	3.1	14.3	6.4
H	9	0.0	3.1	9.4	9.4	10.2	10.9	10.2	12.5	5.5	3.9	3.1	7.0	7.8	3.1	2.3	1.6	13.8	6.2
	10	0.0	3.9	9.4	11.7	10.9	7.0	8.6	9.4	7.0	6.3	3.1	8.6	6.3	3.9	1.6	2.3	13.8	6.2
O	11	0.8	6.3	9.4	10.2	7.0	7.8	14.8	8.6	3.9	3.9	6.3	11.7	3.1	4.7	0.8	0.8	13.2	5.9
	12	3.2	4.0	8.1	7.3	12.1	13.7	4.8	7.3	5.6	8.9	1.6	9.7	6.5	4.8	0.8	1.6	13.5	6.0
U	13	1.5	4.6	5.4	9.2	10.8	8.5	10.8	6.2	10.8	5.4	0.0	13.8	3.8	6.2	0.8	2.3	14.6	6.5
	14	2.3	2.3	3.8	6.9	7.7	10.0	13.8	12.3	8.5	3.8	1.5	9.2	6.2	7.7	2.3	1.5	15.4	6.9
R	15	0.8	2.3	3.1	4.6	7.7	13.8	15.4	8.5	4.6	6.2	0.8	15.4	5.4	8.5	1.5	1.5	15.9	7.1
	16	1.5	1.5	1.5	6.2	12.3	8.5	11.5	8.5	6.9	7.7	5.4	16.2	3.1	6.2	2.3	0.8	15.6	7.0
	17	0.0	2.3	7.8	7.0	5.4	8.5	13.2	9.3	6.2	10.9	4.7	15.5	3.1	2.3	2.3	1.6	14.9	6.7
	18	0.0	0.8	12.4	7.0	7.0	10.9	13.2	9.3	8.5	4.7	3.9	12.4	3.9	3.9	0.8	1.6	14.0	6.3
	19	0.0	3.1	11.8	5.5	11.0	10.2	15.0	9.4	5.5	3.1	3.1	11.0	4.7	3.1	2.4	0.8	13.5	6.1
	20	0.0	1.6	5.5	15.0	11.8	6.3	13.4	4.7	8.7	7.1	2.4	9.4	4.7	5.5	3.1	0.8	14.4	6.4
	21	0.0	0.0	4.7	11.0	10.2	11.0	10.2	7.9	8.7	7.1	5.5	10.2	5.5	4.7	3.1	0.0	14.8	6.6
	22	0.0	0.8	3.1	12.6	13.4	10.2	11.0	7.9	7.1	4.7	4.7	13.4	3.9	5.5	1.6	0.0	14.4	6.4
	23	0.0	0.8	5.6	8.7	14.3	10.3	8.7	11.9	6.3	4.8	6.3	11.1	5.6	3.2	1.6	0.8	14.1	6.3
	24	0.0	3.2	3.2	10.3	10.3	8.7	15.9	9.5	8.7	6.3	1.6	11.9	4.0	4.8	0.8	0.8	14.2	6.3
ALL HOURS		0.6	2.3	6.8	9.9	10.8	9.5	11.4	8.8	6.8	5.5	4.3	11.0	4.6	4.8	1.6	1.5	14.2	6.4

SOURCE: GEORESEARCH, INC.

Table IV - 100

Percentage Frequency Summary for Wind Speed

LIBERTY COUNTY - WHITLASH

(SPRING)

11/18/83 - 07/24/85

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	1.5	6.7	12.6	9.6	15.6	5.9	7.4	8.1	5.2	3.7	14.1	4.4	4.4	0.7	0.0	13.5	6.1
	2	0.0	0.7	5.9	14.8	10.4	8.1	8.1	10.4	8.1	5.9	7.4	13.3	3.0	3.7	0.0	0.0	13.3	6.0
	3	0.0	1.5	6.7	12.6	10.4	11.9	5.9	8.1	11.9	6.7	6.7	11.1	4.4	1.5	0.7	0.0	13.2	5.9
	4	0.0	2.2	5.2	13.4	14.2	9.7	10.4	9.7	5.2	7.5	6.0	9.7	5.2	1.5	0.0	0.0	12.5	5.6
	5	0.8	0.8	6.0	9.0	20.3	10.5	11.3	7.5	6.8	4.5	7.5	11.3	2.3	1.5	0.0	0.0	12.2	5.4
	6	0.8	0.8	5.3	19.5	14.3	11.3	9.8	3.8	5.3	6.0	8.3	9.0	1.5	4.5	0.0	0.0	12.2	5.5
	7	0.8	2.3	6.8	17.3	10.5	13.5	6.8	8.3	3.0	5.3	9.0	9.0	3.0	4.5	0.0	0.0	12.4	5.5
	8	1.5	1.5	8.3	19.5	9.0	7.5	6.0	6.0	7.5	8.3	8.3	9.0	4.5	3.0	0.0	0.0	12.5	5.6
H	9	1.5	3.0	9.0	9.0	11.3	3.0	12.0	12.8	6.8	3.8	6.8	13.5	5.3	0.8	1.5	0.0	13.1	5.9
	10	1.5	1.5	5.3	13.5	6.0	12.0	9.0	8.3	6.0	6.8	6.8	16.5	2.3	3.8	0.8	0.0	13.8	6.2
O	11	0.8	1.5	1.5	10.7	13.0	6.9	13.7	8.4	3.1	6.9	8.4	14.5	5.3	5.3	0.0	0.0	14.5	6.5
	12	0.8	0.8	0.8	5.5	10.2	14.1	9.4	11.7	6.3	7.0	7.8	13.3	4.7	7.8	0.0	0.0	15.4	6.9
U	13	0.7	1.5	1.5	2.2	11.9	11.9	8.9	10.4	12.6	4.4	10.4	11.1	7.4	4.4	0.7	0.0	15.4	6.9
	14	0.7	0.7	3.7	5.9	6.7	11.1	11.1	10.4	9.6	10.4	8.9	8.9	7.4	3.0	0.7	0.7	15.1	6.8
R	15	0.7	1.5	3.7	2.2	8.1	13.3	7.4	13.3	8.9	8.9	3.7	14.8	8.1	3.0	2.2	0.0	15.6	7.0
	16	0.7	0.7	0.7	4.4	9.6	11.9	9.6	13.3	6.7	3.0	8.9	20.0	3.7	5.2	1.5	0.0	16.0	7.1
	17	0.0	0.7	2.2	9.6	5.2	8.1	10.4	9.6	11.9	8.1	5.2	16.3	5.2	7.4	0.0	0.0	15.9	7.1
	18	0.0	0.0	5.2	4.4	5.9	10.4	12.6	10.4	6.7	5.9	8.9	17.8	5.2	5.9	0.7	0.0	15.9	7.1
	19	0.0	0.7	3.7	10.4	5.9	9.6	8.9	12.6	3.7	8.1	8.1	16.3	5.9	5.2	0.7	0.0	15.5	6.9
	20	0.0	1.5	4.4	8.9	8.9	11.1	10.4	7.4	6.7	8.1	5.9	14.8	5.9	5.9	0.0	0.0	14.8	6.6
	21	0.0	1.5	3.7	8.1	15.6	11.1	9.6	10.4	5.9	3.0	8.9	16.3	3.7	1.5	0.7	0.0	13.8	6.2
	22	0.0	1.5	3.0	12.7	10.4	10.4	12.7	9.7	4.5	4.5	7.5	14.9	3.7	4.5	0.0	0.0	14.0	6.3
	23	0.0	2.2	6.0	8.2	11.2	9.7	10.4	9.0	5.2	8.2	5.2	15.7	5.2	3.0	0.7	0.0	14.0	6.3
	24	0.0	1.5	9.0	9.0	11.9	11.9	8.2	7.5	9.7	2.2	8.2	12.7	4.5	3.7	0.0	0.0	13.4	6.0
ALL HOURS		0.5	1.3	4.8	10.1	10.4	10.6	9.5	9.4	7.1	6.2	7.3	13.5	4.7	4.0	0.5	0.0	14.1	6.3

SOURCE: GEORESEARCH, INC.

Table IV - 101

Percentage Frequency Summary for Wind Speed

LIBERTY COUNTY - WHITLASH

(SUMMER)

11/18/83 - 07/24/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)															
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.1	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	2.1	13.7	9.6	11.6	6.8	7.5	11.6	6.2	8.9	7.5	9.6	4.1	0.7	0.0	0.0	12.1	5.4
	2	0.0	4.1	8.9	8.2	14.4	6.8	9.6	8.9	10.3	6.8	8.9	8.9	3.4	0.7	0.0	0.0	12.2	5.4
	3	0.0	1.4	8.2	13.0	8.9	14.4	10.3	8.9	6.8	11.0	4.8	7.5	4.1	0.0	0.7	0.0	12.1	5.4
	4	0.0	1.4	8.9	12.3	13.0	13.0	15.1	6.2	7.5	8.9	2.1	10.3	0.7	0.7	0.0	0.0	11.3	5.1
	5	0.0	1.4	15.1	11.6	12.3	13.0	10.3	11.0	5.5	6.2	5.5	7.5	0.0	0.0	0.7	0.0	10.6	4.7
	6	0.0	0.7	8.2	17.1	17.8	14.4	9.6	6.8	7.5	4.8	4.8	6.8	0.7	0.0	0.0	0.7	10.6	4.7
	7	0.0	2.1	10.3	14.4	18.5	11.0	10.3	7.5	6.8	2.7	9.6	6.2	0.0	0.7	0.0	0.0	10.5	4.7
	8	0.0	3.4	11.6	17.1	12.3	10.3	9.6	9.6	6.2	2.1	11.0	6.2	0.7	0.0	0.0	0.0	10.4	4.6
H	9	0.0	0.7	11.6	11.0	15.8	14.4	10.3	6.8	4.1	4.1	7.5	10.3	2.7	0.7	0.0	0.0	11.5	5.2
	10	0.0	0.7	9.0	9.0	14.5	11.7	10.3	9.7	7.6	7.6	7.6	7.6	3.4	0.7	0.7	0.0	12.3	5.5
O	11	0.0	0.0	4.1	10.3	10.3	14.5	11.7	15.9	8.3	5.5	6.9	9.0	2.1	0.7	0.0	0.7	12.8	5.7
	12	0.0	0.0	2.1	9.7	9.7	16.6	11.7	12.4	10.3	7.6	4.1	12.4	2.1	0.0	0.7	0.7	13.3	6.0
U	13	0.0	0.7	0.7	5.5	15.2	12.4	13.8	9.7	8.3	9.7	8.3	9.7	4.8	0.7	0.7	0.0	13.9	6.2
	14	0.0	0.0	2.8	6.9	9.7	9.0	17.9	10.3	9.0	10.3	10.3	7.6	5.5	0.7	0.0	0.0	13.8	6.2
R	15	0.0	0.7	0.0	11.0	6.2	13.1	9.0	15.2	9.0	12.4	7.6	11.7	2.1	1.4	0.7	0.0	14.1	6.3
	16	0.0	0.0	3.4	7.6	9.7	12.4	10.3	11.0	6.9	13.1	7.6	13.1	2.1	2.1	0.0	0.7	14.2	6.3
	17	0.0	0.0	3.4	4.1	11.7	10.3	11.0	11.7	8.3	12.4	6.9	12.4	5.5	2.1	0.0	0.0	14.6	6.5
	18	0.0	0.0	1.4	4.2	15.3	11.8	11.8	10.4	6.9	6.3	7.6	16.0	5.6	2.8	0.0	0.0	14.7	6.6
	19	0.0	0.0	1.4	9.7	9.0	11.1	8.3	11.1	7.6	9.0	9.7	13.2	5.6	2.1	0.0	2.1	15.1	6.8
	20	0.0	0.0	2.8	7.6	13.2	7.6	13.2	9.7	10.4	9.7	6.3	13.9	2.1	2.1	1.4	0.0	14.2	6.3
	21	0.0	0.0	2.8	6.3	18.1	18.1	12.5	7.6	6.3	9.0	6.9	9.0	2.8	0.0	0.7	0.0	12.6	5.6
	22	0.0	0.7	4.9	6.3	16.7	15.3	16.7	5.6	11.8	6.3	4.2	7.6	2.8	1.4	0.0	0.0	12.3	5.5
	23	0.0	0.0	5.6	11.1	13.2	11.8	13.2	11.1	6.9	9.0	6.3	8.3	1.4	1.4	0.7	0.0	12.5	5.6
	24	0.0	2.1	6.3	9.9	12.7	12.0	8.5	15.5	7.0	5.6	9.9	6.3	2.8	1.4	0.0	0.0	12.4	5.5
ALL HOURS		0.0	0.9	6.1	9.7	12.9	12.2	11.4	10.2	7.7	7.9	7.2	9.6	2.8	0.9	0.3	0.2	12.7	5.7

SOURCE: GEORESEARCH, INC.

Table IV - 102

Percentage Frequency Summary for Wind Speed

LIBERTY COUNTY - WHITLASH

(AUTUMN)

11/18/83 - 07/24/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
								WIND SPEED (METERS/SECOND)									AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	1.5	1.5	4.6	13.8	10.8	12.3	7.7	10.8	4.6	7.7	6.2	7.7	3.1	7.7	0.0	0.0	13.2	5.9
	2	1.5	0.0	4.6	13.8	13.8	12.3	3.1	13.8	7.7	4.6	6.2	7.7	1.5	7.7	1.5	0.0	13.6	6.1
	3	1.5	0.0	7.7	7.7	12.3	20.0	9.2	7.7	6.2	3.1	3.1	7.7	7.7	4.6	1.5	0.0	13.6	6.1
	4	0.0	1.5	4.6	10.8	10.8	13.8	18.5	10.8	3.1	1.5	3.1	9.2	9.2	1.5	1.5	0.0	13.4	6.0
	5	0.0	1.5	3.1	16.9	13.8	21.5	6.2	7.7	1.5	1.5	1.5	13.8	3.1	6.2	1.5	0.0	13.0	5.8
	6	0.0	0.0	7.7	10.8	21.5	15.4	9.2	4.6	6.2	1.5	3.1	6.2	7.7	4.6	1.5	0.0	12.8	5.7
	7	0.0	1.5	10.8	13.8	16.9	15.4	3.1	7.7	4.6	3.1	0.0	7.7	10.8	1.5	1.5	1.5	12.7	5.7
	8	0.0	9.2	7.7	10.8	10.8	18.5	6.2	7.7	4.6	1.5	1.5	10.8	7.7	1.5	1.5	0.0	12.1	5.4
H	9	0.0	1.6	6.3	17.5	17.5	15.9	6.3	6.3	3.2	0.0	3.2	15.9	3.2	0.0	3.2	0.0	12.2	5.5
	10	0.0	0.0	15.9	9.5	15.9	12.7	9.5	3.2	6.3	3.2	1.6	15.9	3.2	1.6	1.6	0.0	12.3	5.5
O	11	0.0	0.0	14.3	7.9	14.3	17.5	9.5	3.2	1.6	4.8	6.3	11.1	4.8	0.0	4.8	0.0	12.9	5.8
	12	0.0	3.4	3.4	8.6	15.5	10.3	13.8	12.1	1.7	3.4	1.7	12.1	5.2	3.4	3.4	1.7	14.2	6.4
U	13	0.0	0.0	9.1	6.1	16.7	10.6	9.1	6.1	4.5	6.1	4.5	9.1	9.1	6.1	1.5	1.5	15.1	6.8
	14	0.0	1.5	4.5	7.6	13.6	10.6	7.6	10.6	4.5	7.6	1.5	15.2	3.0	9.1	1.5	1.5	15.6	7.0
R	15	0.0	1.5	4.5	12.1	7.6	10.6	12.1	9.1	3.0	4.5	9.1	9.1	9.1	3.0	3.0	1.5	15.2	6.8
	16	0.0	4.5	7.6	6.1	12.1	4.5	16.7	9.1	0.0	9.1	6.1	12.1	4.5	7.6	0.0	0.0	14.2	6.4
	17	0.0	3.0	7.6	13.6	3.0	12.1	12.1	7.6	12.1	3.0	6.1	12.1	3.0	3.0	1.5	0.0	13.3	5.9
	18	0.0	6.1	9.1	7.6	13.6	9.1	9.1	10.6	6.1	6.1	4.5	9.1	4.5	4.5	0.0	0.0	12.8	5.7
	19	0.0	0.0	9.2	16.9	7.7	10.8	16.9	3.1	12.3	4.6	1.5	7.7	3.1	4.6	1.5	0.0	12.7	5.7
	20	0.0	0.0	10.8	13.8	7.7	12.3	13.8	7.7	7.7	6.2	7.7	4.6	3.1	3.1	1.5	0.0	12.4	5.5
	21	0.0	1.6	1.6	14.3	12.7	14.3	9.5	14.3	9.5	4.8	4.8	7.9	0.0	4.8	0.0	0.0	12.5	5.6
	22	0.0	3.2	7.9	6.3	19.0	17.5	6.3	9.5	1.6	3.2	6.3	14.3	1.6	3.2	0.0	0.0	12.3	5.5
	23	0.0	1.6	7.9	9.5	12.7	11.1	14.3	11.1	0.0	7.9	3.2	14.3	1.6	4.8	0.0	0.0	12.8	5.7
	24	0.0	5.3	7.0	14.0	12.3	8.8	14.0	5.3	5.3	5.3	8.8	8.8	3.5	1.8	0.0	0.0	11.8	5.3
ALL HOURS		0.2	2.0	7.4	11.2	13.0	13.3	10.1	8.3	4.9	4.4	4.2	10.4	4.7	4.0	1.4	0.3	13.2	5.9

SOURCE: GEORESEARCH, INC.

Table IV - 103

Annual Wind Rose Distribution

LIBERTY COUNTY - WHITLASH

11/18/83 - 07/24/85

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1- 0.4
1.1- 2.0	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	1.2	0.5- 0.9
2.1- 3.0	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	2.0	1.0- 1.3 S
3.1- 4.0	0.4	0.4	0.3	0.2	0.3	0.2	0.4	0.5	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.2	4.1	1.4- 1.8 P
S 4.1- 5.0	0.5	0.3	0.2	0.2	0.1	0.2	0.4	0.6	0.5	0.3	0.2	0.1	0.2	0.2	0.1	0.2	4.1	1.9- 2.2 E
P 5.1- 6.0	0.7	0.6	0.4	0.3	0.1	0.1	0.4	1.0	0.7	0.4	0.3	0.2	0.2	0.1	0.2	0.3	6.0	2.3- 2.7 E
E 6.1- 7.0	0.7	0.5	0.4	0.2	0.1	0.1	0.4	0.7	0.6	0.4	0.3	0.2	0.2	0.1	0.2	0.2	5.1	2.8- 3.1 D
E 7.1- 8.0	1.1	0.8	0.3	0.2	0.1	0.2	0.4	0.8	0.6	0.4	0.4	0.3	0.3	0.1	0.2	0.3	6.5	3.2- 3.6
D 8.1- 9.0	0.7	0.6	0.3	0.1	0.0	0.1	0.4	0.5	0.5	0.4	0.5	0.2	0.2	0.2	0.2	0.2	5.0	3.7- 4.0 M
9.1-10.0	1.0	0.8	0.3	0.1	0.0	0.1	0.4	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.3	6.2	4.1- 4.5 E
M 10.1-11.0	0.8	0.9	0.2	0.1	0.0	0.1	0.4	0.4	0.4	0.2	0.3	0.3	0.2	0.3	0.1	0.2	5.0	4.6- 4.9 T
I 11.1-12.0	0.8	0.8	0.1	0.1	0.0	0.1	0.4	0.6	0.5	0.2	0.3	0.4	0.3	0.3	0.3	0.3	5.6	5.0- 5.4 E
L 12.1-13.0	0.7	0.6	0.1	0.0	0.0	0.1	0.5	0.5	0.3	0.2	0.2	0.2	0.2	0.4	0.2	0.3	4.4	5.5- 5.8 R
E 13.1-14.0	0.9	0.5	0.0	0.0	0.0	0.0	0.5	0.4	0.4	0.2	0.2	0.3	0.3	0.3	0.3	0.5	5.0	5.9- 6.3 S
S 14.1-15.0	0.6	0.3	0.0	0.0	0.0	0.1	0.5	0.3	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.5	3.6	6.4- 6.7 /
/ 15.1-16.0	0.5	0.3	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.1	0.2	0.3	0.3	0.3	0.2	0.3	3.3	6.8- 7.2 S
H 16.1-17.0	0.6	0.2	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.1	0.2	0.4	0.4	0.3	0.3	0.4	3.6	7.3- 7.6 E
O 17.1-18.0	0.3	0.2	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.1	0.1	0.4	0.3	0.4	0.2	0.2	2.6	7.7- 8.0 C
U 18.1-19.0	0.5	0.2	0.0	0.0	0.0	0.0	0.6	0.1	0.1	0.0	0.1	0.4	0.5	0.4	0.2	0.4	3.5	8.1- 8.5 O
R 19.1-20.0	0.4	0.2	0.0	0.0	0.0	0.1	0.4	0.1	0.0	0.0	0.0	0.1	0.4	0.4	0.2	0.2	2.5	8.6- 8.9 N
20.1-25.0	0.9	0.4	0.0	0.0	0.0	0.2	1.2	0.3	0.1	0.1	0.2	1.3	2.0	1.6	0.6	0.8	9.8	9.0-11.2 D
25.1-30.0	0.5	0.2	0.0	0.0	0.0	0.1	0.6	0.1	0.0	0.1	0.0	0.9	1.4	1.0	0.3	0.4	5.5	11.3-13.4
30.1-35.0	0.3	0.2	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.4	0.8	0.5	0.1	0.2	2.9	13.5-15.6
35.1-40.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.3	0.1	0.1	1.2	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.5	>17.9
CALM																	0.3	CALM
TOTAL	13.7	9.3	2.8	1.9	1.1	2.0	9.3	8.7	6.4	3.8	4.2	7.4	9.7	8.0	4.7	6.7	100.0	TOTAL
AV SPEED (MPH)	13.0	11.4	7.5	6.4	5.6	10.8	14.4	9.6	9.1	9.4	10.5	18.1	20.4	19.4	15.1	14.9	13.6	AV SPEED (MPH)
AV SPEED (M/SEC)	5.8	5.1	3.3	2.9	2.5	4.8	6.4	4.3	4.1	4.2	4.7	8.1	9.1	8.7	6.8	6.7	6.1	AV SPEED (M/SEC)

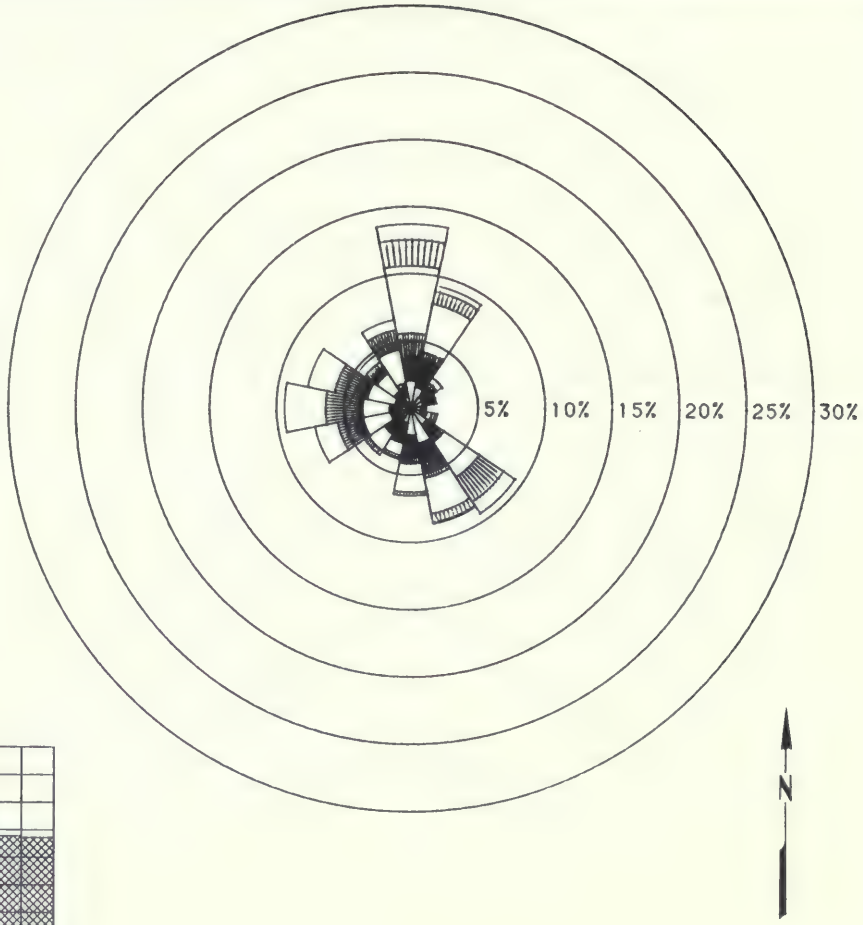
SOURCE: GEORESEARCH, INC.

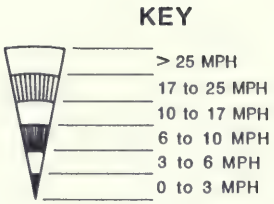
Figure IV - 11

Annual Wind Rose

LIBERTY COUNTY - WHITLASH

(1983 - 1985)





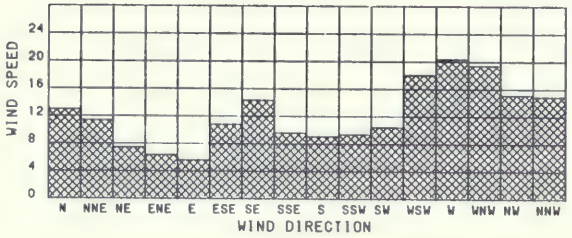


Table IV - 104

Coefficients of Weibull Distribution

LIBERTY COUNTY - WHITLASH

11/18/83 - 07/24/85

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.3683	1.4608
FEBRUARY	6.4123	1.7495
MARCH	5.7340	1.6656
APRIL	7.8202	1.7764
MAY	6.9605	1.8373
JUNE	6.6646	1.8168
JULY	5.8372	2.0553
AUGUST	5.9769	1.9078
SEPTEMBER	7.5464	1.5741
OCTOBER	NO DATA	NO DATA
NOVEMBER	5.1320	1.8202
DECEMBER	6.2746	1.7270
YEAR	6.4634	1.7458

SOURCE: GEORESEARCH, INC.

NORRIS HILL
MADISON COUNTY

The Norris Hill site is located ten miles north of Ennis at 45 29 42 N and 111 41 57 W (Site No. 157 on Map II-1). Elevation at the site is 5,675 feet. This monitoring site is part of the wind monitoring program of the Montana Department of Natural Resources and Conservation.

The site is located at the crest of Norris Hill on a finger ridge. Norris Hill is at the head of the Madison River valley, which runs more or less due north. A hill to the east and southeast that is approximately 525 feet higher than the site could affect the winds at the site. However, both the ridge on which the site is located and the hill to the east have slopes in the 20 to 50 degree range and the site is otherwise well exposed to the wind. In addition, there is a very evident funneling of winds up the draw where US 287 crests Norris Hill from the south, which could compensate for the hill to the east. The site is representative of a range of hills that runs approximately east and west between the Madison and Jefferson ranges. The range of hills is six to eight miles long, several miles wide and contains many knobs and ridges that would be suitable for the installation of wind generating equipment. The site is just west of state Highway 287, but winter access still can be difficult.

The site is located on private land. Much of the land in the area is held by the Bureau of Land Management; the state also owns some land nearby. Electrical service in the area is provided by the Montana Power Company. A 169 kV line runs south of the site and a 100 kV line runs to the north. Both lines come out of Montana Power's Madison powerhouse in Beartrap Canyon, three miles east of the site. The nearest commercial airport is outside of Bozeman, 35 miles to the northeast. There is a private landing field five miles south of the site in the Madison valley.

Wind data collection began January 10, 1984. Data through March 31, 1986 was available for analysis. Monitoring is scheduled to continue at least through June 1987. A Met One anemometer and a Campbell Scientific datalogger were used. The anemometer height was 33 feet.

Data recovery was poor to excellent, ranging from 45.6 percent in November to 99.9 percent in May, July, and September. Overall data recovery was 85.8 percent.

Average monthly wind speeds ranged from 11.6 miles per hour in July to 22.9 miles per hour in December. Average annual wind speed was 17.0 miles per hour.

Average monthly wind power ranged from 99.3 watts/m^2 in July to 832.3 watts/m^2 in December.

Average seasonal speeds were 12.9 miles per hour in the summer, 16.8 miles per hour in the autumn, 21.5 miles per hour in the winter, and 16.4 miles per hour in the spring. In the winter and spring, the highest wind speed occurred in early to late afternoon. High winds in the summer were a little later than in the winter and spring. The highest winds in the autumn were between noon and late afternoon. Diurnal range of average wind speeds was greatest in the summer, least in the winter, and about the same in spring and autumn.

The wind blew most frequently from the south-southeast through the southwest, that is, from directly down the valley. The winds came from the north-northeast and northeast about 20 percent of the time, and otherwise came very infrequently from the other directions. By direction, average wind speeds ranged from 7.5 miles per hour from the east-southeast to 20.0 miles per hour from the south and south-southwest.

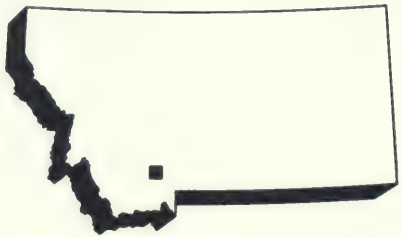


Table IV - 105

Monthly Wind Speed Distribution

MADISON COUNTY - NORRIS HILL

01/10/84 - 03/31/86

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	1.5	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.2	CALM
0.1-1.0	0.0	0.3	0.2	0.3	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1- 0.4
1.1-2.0	0.7	0.7	0.7	0.7	0.5	0.6	0.6	0.5	0.9	0.6	0.8	1.0	0.7	0.5- 0.9
2.1-3.0	1.0	1.3	1.2	0.8	0.7	1.3	1.0	1.6	1.4	0.4	0.9	1.0	1.1	1.0- 1.3
3.1-4.0	1.2	1.6	2.4	1.6	2.0	2.4	3.0	2.4	2.8	1.8	1.2	1.0	2.0	1.4- 1.8
4.1-5.0	1.3	1.8	2.6	2.1	2.6	3.2	3.9	3.8	3.2	0.9	1.1	1.6	2.4	1.9- 2.2
5.1-6.0	2.2	2.3	4.3	4.0	4.6	6.0	6.3	5.1	3.3	2.2	2.3	1.4	3.8	2.3- 2.7
6.1-7.0	1.4	1.8	2.7	2.5	4.0	4.0	5.9	3.5	4.6	2.7	1.4	1.9	3.1	2.8- 3.1
7.1-8.0	2.0	2.1	4.1	3.6	5.9	6.0	7.1	5.5	6.3	2.2	3.7	1.9	4.2	3.2- 3.6
8.1-9.0	2.1	2.9	2.9	3.1	5.0	5.3	7.1	5.5	5.6	1.5	3.5	2.6	4.0	3.7- 4.0
9.1-10.0	3.7	3.8	3.8	3.9	5.7	6.9	7.4	5.9	6.4	2.8	4.3	2.2	4.8	4.1- 4.5
10.1-11.0	2.3	2.1	3.0	4.3	4.6	5.2	6.6	6.1	4.2	3.2	3.0	1.1	3.8	4.6- 4.9
11.1-12.0	2.5	3.1	3.8	4.4	6.5	7.2	8.4	7.4	5.8	3.3	5.2	2.3	5.0	5.0- 5.4
12.1-13.0	2.2	2.4	3.4	4.4	5.3	4.7	5.8	5.3	4.0	2.9	2.7	2.5	3.8	5.5- 5.8
13.1-14.0	2.2	3.3	5.1	5.8	6.4	5.7	7.1	8.3	4.4	2.5	5.8	2.3	4.9	5.9- 6.3
14.1-15.0	2.3	2.0	4.2	4.6	4.9	4.7	4.6	5.9	3.6	2.2	3.3	2.1	3.7	6.4- 6.7
15.1-16.0	1.9	2.7	4.4	4.8	4.0	4.3	5.2	4.0	4.0	2.9	3.7	1.7	3.6	6.8- 7.2
16.1-17.0	3.4	3.6	5.6	4.8	4.0	5.6	5.2	5.2	5.4	5.3	4.9	3.3	4.6	7.3- 7.6
17.1-18.0	2.9	2.9	3.7	3.3	3.4	3.6	2.8	2.6	3.8	4.7	4.4	3.1	3.3	7.7- 8.0
18.1-19.0	3.2	4.1	5.1	4.6	3.1	4.3	4.3	2.8	3.9	5.4	6.1	3.3	4.0	8.1- 8.5
19.1-20.0	3.5	3.4	4.0	3.9	2.9	2.9	2.3	2.4	3.6	3.4	5.9	2.2	3.3	8.6- 8.9
20.1-25.0	19.4	16.7	14.5	16.7	11.7	10.1	4.8	9.5	12.8	20.0	18.3	16.7	14.0	9.0-11.2
25.1-30.0	17.6	14.0	9.1	7.5	6.1	3.4	0.4	3.9	5.3	16.3	9.6	19.4	9.3	11.3-13.4
30.1-35.0	12.4	11.3	5.2	4.3	2.8	1.5	0.0	1.8	2.9	9.4	4.4	11.5	5.7	13.5-15.6
35.1-40.0	4.7	6.0	1.9	2.8	1.9	0.4	0.1	0.6	0.9	2.4	2.9	8.3	2.8	15.7-17.9
>40.0	2.4	3.7	2.0	1.4	1.3	0.7	0.0	0.3	0.6	1.0	0.8	5.5	1.7	>17.9
AVERAGE SPEED (MPH)	21.1	20.9	17.1	17.0	15.1	13.6	11.6	13.5	14.5	20.0	17.9	22.9	17.0	
AVERAGE SPEED (M/SEC)	9.4	9.3	7.6	7.6	6.8	6.1	5.2	6.0	6.5	8.9	8.0	10.2	7.6	
AVERAGE WIND POWER (WATTS/M**2)	677.5	688.1	407.4	380.5	297.1	197.3	99.3	187.0	245.0	517.4	400.9	832.3	414.3	
PERCENT DATA RECOVERY	93.1	89.1	73.5	95.4	99.9	99.0	99.9	99.8	99.9	53.0	45.6	83.7	85.8	

S P E E D / H O U R S

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 16743
PERCENTAGE DATA RECOVERY = 85.8

SOURCE: GEORESEARCH, INC.

Table IV - 106

Percentage Frequency Summary for Wind Speed

MADISON COUNTY - NORRIS HILL

(WINTER)

01/10/84 - 03/31/86

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
		WIND SPEED (METERS/SECOND)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	
	1	0.5	0.9	1.9	4.2	6.0	4.2	3.3	4.7	5.1	8.4	7.9	19.5	12.6	11.6	6.0	3.3	21.2	9.5
	2	0.5	0.9	2.8	2.8	4.2	5.1	5.1	4.2	6.5	4.7	8.8	20.0	12.1	14.0	6.0	2.3	21.4	9.6
	3	0.9	1.4	1.4	3.3	4.2	5.2	5.6	5.6	5.6	4.7	8.5	17.8	11.3	18.3	4.2	1.9	21.2	9.5
	4	1.0	1.0	2.4	1.9	3.4	6.3	3.9	6.3	5.3	9.2	8.7	17.9	11.6	15.0	3.4	2.9	21.1	9.4
	5	1.0	0.5	2.9	3.9	1.5	6.3	3.9	5.3	4.9	10.7	8.7	19.4	11.2	13.1	4.4	2.4	21.0	9.4
	6	1.0	1.5	1.5	4.4	1.5	7.3	4.4	3.9	4.4	8.7	7.8	20.4	13.1	14.1	3.4	2.9	21.1	9.4
	7	1.0	1.0	2.4	1.0	2.9	6.8	5.3	5.8	3.4	7.3	7.8	25.2	9.2	14.6	3.9	2.4	21.4	9.5
	8	1.0	0.0	2.5	4.9	2.9	4.9	5.4	2.0	6.4	7.4	9.3	18.6	12.7	14.7	4.4	2.9	21.5	9.6
H	9	0.5	0.5	2.0	3.4	3.9	6.9	4.9	6.4	2.5	6.9	6.4	23.2	10.8	14.8	5.9	1.0	21.3	9.5
	10	0.5	0.0	2.0	4.5	1.0	7.4	5.4	4.5	5.0	7.4	6.4	20.8	14.4	12.9	5.0	3.0	21.5	9.6
O	11	0.5	2.0	1.5	3.0	3.0	4.5	5.5	5.0	3.5	6.0	7.0	25.0	12.0	14.0	5.5	2.0	21.7	9.7
	12	0.5	2.0	3.6	1.5	3.1	4.1	5.6	5.6	2.6	5.6	5.1	26.0	14.8	13.3	5.1	1.5	21.5	9.6
U	13	0.5	0.9	3.2	0.5	3.2	5.5	4.6	5.1	2.3	5.5	7.8	21.2	12.9	17.5	5.5	3.7	22.8	10.2
	14	0.5	0.5	1.4	2.3	4.6	4.2	5.6	4.6	5.1	5.6	6.5	18.1	15.3	18.5	3.2	4.2	22.7	10.1
R	15	0.5	0.5	0.9	2.4	4.7	6.2	4.3	3.3	4.3	8.1	6.6	16.6	17.1	14.2	6.2	4.3	22.6	10.1
	16	0.5	0.5	0.5	4.8	3.8	6.7	2.9	5.2	5.2	3.3	8.6	20.0	13.3	13.8	7.1	3.8	22.3	10.0
	17	0.5	0.0	1.9	5.3	3.8	6.7	5.3	4.3	3.8	4.8	4.3	23.0	12.9	15.3	5.3	2.9	21.8	9.7
	18	0.5	0.5	2.9	4.8	3.8	7.2	4.8	3.8	3.8	4.8	4.3	21.5	16.7	11.0	7.7	1.9	21.5	9.6
	19	0.5	1.0	3.4	3.8	5.8	7.2	3.4	5.3	3.4	5.3	5.8	18.3	17.3	12.0	5.3	2.4	21.1	9.4
	20	0.5	1.0	2.9	4.9	5.3	8.3	6.8	4.9	2.9	4.9	3.4	20.4	16.0	9.7	5.3	2.9	20.5	9.2
	21	0.5	1.0	2.5	4.4	3.9	7.4	4.4	6.9	3.9	5.4	2.5	23.0	16.2	10.3	4.9	2.9	21.2	9.5
	22	0.0	1.5	4.5	3.5	4.5	4.0	4.5	6.9	3.0	5.0	5.9	24.3	14.9	9.4	4.5	4.0	21.3	9.5
	23	0.0	2.0	3.0	5.5	4.0	3.5	2.5	6.0	5.0	5.5	7.5	24.5	10.5	14.0	3.5	3.0	21.1	9.4
	24	0.5	1.0	3.6	6.6	3.1	5.6	3.1	4.6	4.6	9.7	5.1	21.4	12.8	12.8	3.6	2.0	20.2	9.0
ALL HOURS		0.6	0.9	2.4	3.6	3.7	5.9	4.6	5.0	4.3	6.4	6.7	21.0	13.4	13.7	5.0	2.8	21.5	9.6

SOURCE: GEORESEARCH, INC.

Table IV - 107

Percentage Frequency Summary for Wind Speed

MADISON COUNTY - NORRIS HILL

(SPRING)

01/10/84 - 03/31/86

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	1.1	1.6	5.9	6.4	12.2	13.3	9.6	8.5	5.9	8.0	15.4	6.4	3.7	1.6	0.5	15.8	7.1
	2	0.0	0.0	4.3	6.9	6.9	10.1	10.6	12.8	6.9	6.4	7.4	16.0	5.3	5.3	0.5	0.5	15.7	7.0
	3	0.0	1.6	5.3	6.4	4.8	8.5	13.8	5.9	10.1	10.1	5.3	16.5	6.4	4.3	0.5	0.5	15.6	7.0
	4	0.0	2.1	2.7	10.1	9.0	6.4	8.0	11.7	8.5	5.9	8.5	16.0	5.9	4.3	0.5	0.5	15.4	6.9
	5	0.0	1.6	2.7	8.0	12.2	6.9	6.4	10.1	8.0	9.6	10.6	11.7	5.3	3.7	3.2	0.0	15.4	6.9
	6	0.0	1.6	3.7	6.4	8.0	10.7	8.6	9.1	7.0	11.2	9.1	12.3	5.3	5.9	1.1	0.0	15.5	6.9
	7	0.0	1.1	4.3	7.5	8.0	8.0	10.7	10.2	8.6	7.0	5.9	18.7	5.9	2.7	1.1	0.5	15.4	6.9
	8	0.5	2.1	2.1	10.2	5.9	3.7	12.3	13.4	11.8	7.0	5.9	13.4	6.4	3.2	1.1	1.1	15.4	6.9
H	9	0.0	2.1	4.8	6.4	4.8	8.0	12.8	9.1	9.6	11.2	5.3	13.4	4.8	4.3	1.6	1.6	15.7	7.0
	10	0.0	1.1	3.2	5.9	8.0	8.0	8.0	11.2	8.0	8.6	10.7	14.4	3.7	5.3	2.7	1.1	16.4	7.3
O	11	0.0	0.0	3.2	8.6	5.9	10.2	4.8	10.2	11.2	8.6	7.5	13.4	7.0	5.3	1.6	2.7	16.8	7.5
	12	0.0	0.5	2.2	8.1	5.9	8.1	4.3	11.8	10.2	9.7	8.1	16.1	5.9	3.8	2.7	2.7	17.3	7.7
U	13	0.0	0.5	1.6	8.5	7.4	6.3	5.8	3.7	10.6	9.0	6.9	21.2	9.5	3.7	3.2	2.1	18.1	8.1
	14	0.0	0.5	2.1	4.8	6.9	6.3	6.3	9.0	6.3	11.1	10.6	17.5	7.4	4.2	4.8	2.1	18.3	8.2
R	15	0.0	0.5	0.5	5.8	6.9	7.4	7.4	9.5	6.9	6.3	13.2	13.8	9.0	5.8	2.6	4.2	18.5	8.3
	16	0.0	0.0	3.7	3.2	7.4	6.3	7.9	8.5	6.3	9.5	8.5	19.0	7.4	6.9	3.7	1.6	18.3	8.2
	17	0.0	0.0	2.1	3.2	6.9	6.3	5.3	14.8	10.1	5.3	6.3	20.6	6.3	7.4	3.2	2.1	18.3	8.2
	18	0.0	0.0	2.1	4.8	6.9	9.5	6.3	10.6	11.6	7.9	6.9	14.3	8.5	6.3	3.2	1.1	17.7	7.9
	19	0.0	0.5	4.3	6.4	4.8	6.9	8.0	13.3	6.4	8.0	8.0	18.1	5.9	6.4	2.1	1.1	17.0	7.6
	20	0.0	0.5	2.7	7.0	9.1	8.0	12.3	8.6	9.6	7.0	6.4	16.0	4.3	5.9	1.6	1.1	16.1	7.2
	21	0.0	0.5	2.1	11.8	8.6	9.1	5.9	10.7	7.0	8.6	8.6	17.6	4.3	4.3	1.1	0.0	15.3	6.8
	22	0.0	1.1	1.6	7.5	11.2	8.6	10.7	9.1	9.1	10.2	5.3	17.6	3.2	3.2	1.1	0.5	15.1	6.7
	23	0.0	0.5	3.8	4.8	10.2	10.2	12.9	8.6	10.2	6.5	8.6	15.6	3.2	2.7	1.6	0.5	15.1	6.8
	24	0.0	1.6	3.8	3.8	9.2	9.2	9.2	10.3	12.0	9.8	7.1	14.1	4.3	3.8	0.5	1.1	15.3	6.8
ALL HOURS		0.0	0.9	2.9	6.7	7.6	8.1	8.8	10.1	8.9	8.3	7.9	16.0	5.9	4.7	2.0	1.2	16.4	7.3

SOURCE: GEORESEARCH, INC.

Table IV - 108

Percentage Frequency Summary for Wind Speed

MADISON COUNTY - NORRIS HILL

(SUMMER)

01/10/84 - 03/31/86

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (METERS/SECOND)																AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	1.6	6.5	9.2	10.9	14.7	13.0	15.8	6.0	12.0	5.4	4.3	0.5	0.0	0.0	0.0	11.5	5.1
	2	0.5	1.6	5.4	14.1	10.9	14.1	15.8	9.8	8.7	6.5	4.9	7.6	0.0	0.0	0.0	0.0	11.1	5.0
	3	0.0	0.5	6.5	16.3	12.5	13.0	14.7	10.3	9.8	5.4	4.3	4.9	1.6	0.0	0.0	0.0	10.9	4.9
	4	0.0	0.5	8.2	10.3	16.3	12.5	13.6	12.5	6.0	7.6	6.5	4.9	1.1	0.0	0.0	0.0	11.1	5.0
	5	0.5	0.5	4.3	11.4	12.0	11.4	18.5	12.5	12.0	7.1	4.3	5.4	0.0	0.0	0.0	0.0	11.5	5.1
	6	0.5	0.5	4.3	12.0	10.3	14.7	17.4	12.0	8.2	5.4	8.2	6.0	0.5	0.0	0.0	0.0	11.5	5.1
	7	0.5	1.6	2.7	7.1	15.8	13.6	15.8	13.0	10.9	6.5	6.0	5.4	1.1	0.0	0.0	0.0	11.7	5.2
	8	0.0	1.1	4.3	6.0	13.6	12.5	15.8	12.5	10.3	9.8	7.6	6.0	0.5	0.0	0.0	0.0	12.1	5.4
H	9	0.0	0.0	5.4	3.8	12.0	13.6	16.3	16.8	11.4	5.4	7.6	6.5	1.1	0.0	0.0	0.0	12.4	5.5
	10	0.0	0.0	5.5	7.1	10.9	10.9	12.6	16.9	9.3	11.5	4.4	8.2	1.6	1.1	0.0	0.0	12.9	5.8
O	11	0.0	0.5	3.8	8.8	9.9	12.1	15.4	12.6	6.6	11.0	5.5	8.8	3.8	0.5	0.0	0.5	13.2	5.9
	12	0.0	0.0	3.3	9.4	10.5	10.5	15.5	11.6	11.6	6.1	5.0	9.9	3.3	1.7	1.7	0.0	13.7	6.1
U	13	0.0	0.0	1.1	12.5	12.0	6.0	14.1	17.9	7.6	7.1	2.2	12.0	2.7	3.8	0.5	0.5	14.0	6.3
	14	0.0	0.0	1.6	6.5	7.6	18.5	7.6	14.1	11.4	6.0	3.8	14.7	3.3	3.8	0.0	1.1	14.8	6.6
R	15	0.0	0.0	0.0	6.5	10.3	13.0	12.5	10.9	12.5	5.4	10.9	10.3	1.6	3.8	1.1	1.1	15.0	6.7
	16	0.0	0.0	0.5	4.9	4.3	14.7	12.5	12.0	9.8	10.3	8.7	12.5	3.3	5.4	0.5	0.5	15.8	7.0
	17	0.0	0.0	0.0	8.7	7.1	7.1	10.9	9.8	12.5	13.6	7.1	15.2	5.4	1.6	0.5	0.5	15.6	7.0
	18	0.0	0.0	1.1	4.9	9.3	9.8	10.9	8.7	13.7	13.7	7.7	12.6	3.3	2.7	1.1	0.5	15.3	6.9
	19	0.0	0.0	1.6	7.7	8.7	12.6	9.3	11.5	8.7	12.0	9.8	12.0	3.3	1.6	0.5	0.5	14.5	6.5
	20	0.0	0.0	4.9	8.8	8.2	12.1	11.0	11.5	7.7	11.5	8.2	12.1	1.6	1.6	0.0	0.5	13.6	6.1
	21	0.0	0.5	6.0	9.9	8.8	13.7	17.0	8.8	9.3	7.7	7.1	7.1	1.6	1.1	1.1	0.0	12.6	5.6
	22	0.0	2.2	6.0	15.4	7.7	13.7	14.3	8.8	11.0	4.4	3.8	12.1	0.5	0.0	0.0	0.0	11.6	5.2
	23	0.0	1.6	3.8	12.1	13.2	15.4	15.4	8.2	9.3	8.2	3.8	8.2	0.5	0.0	0.0	0.0	11.5	5.1
	24	0.0	1.1	6.7	12.2	13.3	13.9	8.3	17.2	6.1	5.6	8.3	7.2	0.0	0.0	0.0	0.0	11.3	5.0
ALL HOURS		0.1	0.6	3.9	9.4	10.7	12.7	13.7	12.3	9.6	8.3	6.3	8.9	1.8	1.2	0.3	0.3	12.9	5.8

SOURCE: GEORESEARCH, INC.

Table IV - 109

Percentage Frequency Summary for Wind Speed

MADISON COUNTY - NORRIS HILL

(AUTUMN)

01/10/84 - 03/31/86

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (METERS/SECOND)																	
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.1	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	1.7	3.3	8.3	7.4	9.9	8.3	6.6	7.4	10.7	9.1	16.5	5.8	4.1	0.8	0.0	15.6	7.0
	2	0.0	1.7	5.0	2.5	8.3	8.3	6.6	8.3	8.3	10.7	12.4	17.4	7.4	2.5	0.8	0.0	16.0	7.1
	3	0.0	2.5	1.7	5.0	6.6	7.4	6.6	12.4	9.1	10.7	9.9	16.5	7.4	3.3	0.0	0.8	16.1	7.2
	4	0.0	0.0	5.0	3.3	6.6	8.3	5.8	14.0	7.4	10.7	11.6	18.2	5.8	2.5	0.8	0.0	16.1	7.2
	5	0.0	0.8	1.7	7.5	8.3	10.0	9.2	5.8	5.0	13.3	12.5	15.8	5.0	4.2	0.0	0.8	16.0	7.2
	6	0.0	1.7	1.7	4.2	10.0	6.7	11.7	10.0	6.7	5.8	11.7	18.3	5.8	5.8	0.0	0.0	16.2	7.2
	7	0.8	1.7	0.8	4.2	9.2	7.5	15.0	8.3	5.0	10.0	5.0	17.5	10.0	3.3	1.7	0.0	16.2	7.2
	8	0.8	1.7	4.2	6.7	5.8	7.5	11.7	6.7	6.7	10.8	6.7	18.3	9.2	3.3	0.0	0.0	15.8	7.1
H	9	1.7	1.7	0.8	5.0	10.8	8.3	8.3	7.5	8.3	7.5	8.3	16.7	11.7	3.3	0.0	0.0	16.0	7.2
	10	0.8	1.7	2.5	8.3	5.8	6.7	10.0	6.7	8.3	8.3	7.5	22.5	2.5	7.5	0.8	0.0	16.4	7.3
O	11	0.8	0.0	4.2	3.3	7.5	7.5	10.8	9.2	5.8	6.7	6.7	20.8	5.8	8.3	1.7	0.8	17.3	7.7
	12	0.0	0.0	5.8	4.2	6.7	7.5	5.8	10.0	5.8	6.7	7.5	16.7	10.8	9.2	1.7	1.7	18.3	8.2
U	13	0.0	0.0	5.8	5.0	4.1	9.1	5.8	5.8	7.4	8.3	6.6	15.7	10.7	9.9	3.3	2.5	19.1	8.5
	14	0.0	0.8	1.7	2.5	9.1	7.4	9.1	5.8	5.0	5.8	5.8	20.7	10.7	11.6	1.7	2.5	19.3	8.6
R	15	0.0	0.0	2.5	3.3	5.8	11.6	6.6	5.0	5.0	8.3	7.4	19.8	9.9	9.9	3.3	1.7	19.1	8.6
	16	0.0	0.0	1.7	3.3	5.8	10.7	9.1	5.8	4.1	8.3	9.1	21.5	8.3	9.1	2.5	0.8	18.8	8.4
	17	0.0	0.0	0.8	1.7	9.1	10.7	5.8	6.6	7.4	9.1	8.3	21.5	8.3	9.9	0.8	0.0	18.3	8.2
	18	0.0	0.8	1.7	2.5	9.2	7.5	10.0	8.3	8.3	11.7	9.2	13.3	8.3	8.3	0.8	0.0	17.2	7.7
	19	0.0	0.8	3.3	4.2	6.7	15.0	8.3	2.5	6.7	11.7	11.7	15.8	7.5	5.0	0.8	0.0	16.4	7.3
	20	0.0	0.0	4.2	3.3	12.5	8.3	9.2	10.0	5.8	10.8	8.3	13.3	8.3	5.0	0.8	0.0	15.8	7.1
	21	0.0	0.8	5.0	5.0	8.3	14.2	5.0	5.8	8.3	10.8	10.0	14.2	6.7	5.0	0.0	0.8	15.8	7.1
	22	0.0	0.8	5.9	6.7	5.0	8.4	10.9	5.9	6.7	10.9	10.9	17.6	4.2	4.2	0.8	0.8	15.8	7.0
	23	0.0	0.8	4.2	10.9	8.4	7.6	5.9	8.4	5.9	9.2	11.8	16.8	5.9	1.7	2.5	0.0	15.4	6.9
	24	0.0	0.8	2.5	5.9	11.9	8.5	11.0	7.6	7.6	8.5	5.9	20.3	5.1	4.2	0.0	0.0	15.4	6.9
ALL HOURS		0.2	0.9	3.2	4.9	7.9	8.9	8.6	7.6	6.8	9.4	8.9	17.7	7.6	5.9	1.1	0.6	16.8	7.5

SOURCE: GEORESEARCH, INC.

Table IV - 110

Annual Wind Rose Distribution

MADISON COUNTY - NORRIS HILL

01/10/84 - 03/31/86

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1- 0.4
1.1- 2.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.7	0.5- 0.9
2.1- 3.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0	1.1	1.0- 1.3 S
3.1- 4.0	0.0	0.1	0.4	0.2	0.1	0.0	0.1	0.1	0.1	0.3	0.5	0.0	0.0	0.0	0.0	0.0	2.0	1.4- 1.8 P
S 4.1- 5.0	0.1	0.2	0.6	0.2	0.1	0.0	0.0	0.1	0.2	0.4	0.4	0.0	0.0	0.0	0.0	0.0	2.4	1.9- 2.2 E
P 5.1- 6.0	0.1	0.3	0.9	0.2	0.1	0.1	0.1	0.1	0.4	0.6	0.7	0.0	0.0	0.0	0.0	0.0	3.8	2.3- 2.7 E
E 6.1- 7.0	0.1	0.4	0.8	0.1	0.0	0.0	0.0	0.1	0.4	0.4	0.5	0.0	0.0	0.0	0.0	0.0	3.1	2.8- 3.1 D
E 7.1- 8.0	0.1	0.6	0.8	0.2	0.0	0.0	0.0	0.2	0.7	0.8	0.6	0.0	0.0	0.0	0.0	0.0	4.2	3.2- 3.6
D 8.1- 9.0	0.1	0.6	0.7	0.1	0.0	0.0	0.1	0.2	0.6	0.8	0.6	0.1	0.0	0.0	0.0	0.0	4.0	3.7- 4.0 M
9.1-10.0	0.1	0.8	0.7	0.1	0.1	0.0	0.1	0.3	0.9	1.0	0.5	0.0	0.0	0.0	0.0	0.0	4.8	4.1- 4.5 E
M 10.1-11.0	0.2	0.6	0.6	0.1	0.0	0.0	0.0	0.3	0.7	0.7	0.5	0.0	0.0	0.0	0.0	0.0	3.8	4.6- 4.9 T
I 11.1-12.0	0.1	0.9	0.3	0.1	0.0	0.0	0.1	0.3	1.2	1.0	0.7	0.1	0.0	0.0	0.0	0.0	5.0	5.0- 5.4 E
L 12.1-13.0	0.2	0.6	0.3	0.0	0.0	0.0	0.1	0.3	0.9	0.7	0.5	0.1	0.1	0.0	0.0	0.0	3.8	5.5- 5.8 R
E 13.1-14.0	0.1	0.7	0.4	0.1	0.0	0.0	0.1	0.4	1.4	0.7	0.8	0.1	0.0	0.0	0.0	0.0	4.9	5.9- 6.3 S
S 14.1-15.0	0.1	0.4	0.3	0.1	0.0	0.0	0.0	0.4	1.1	0.6	0.5	0.1	0.1	0.0	0.0	0.0	3.7	6.4- 6.7 /
/ 15.1-16.0	0.1	0.5	0.2	0.1	0.0	0.0	0.0	0.3	1.2	0.6	0.4	0.1	0.0	0.0	0.0	0.0	3.6	6.8- 7.2 S
H 16.1-17.0	0.1	0.7	0.3	0.0	0.0	0.0	0.0	0.4	1.5	0.8	0.7	0.1	0.0	0.0	0.0	0.0	4.6	7.3- 7.6 E
O 17.1-18.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.3	1.3	0.5	0.3	0.1	0.0	0.0	0.0	0.0	3.3	7.7- 8.0 C
U 18.1-19.0	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.4	1.6	0.8	0.3	0.1	0.0	0.0	0.0	0.0	4.0	8.1- 8.5 O
R 19.1-20.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.3	1.3	0.7	0.3	0.1	0.0	0.0	0.0	0.0	3.3	8.6- 8.9 N
20.1-25.0	0.1	0.8	0.7	0.1	0.0	0.0	0.0	1.9	5.8	2.7	1.4	0.2	0.1	0.0	0.0	0.1	14.0	9.0-11.2 D
25.1-30.0	0.1	0.3	0.1	0.1	0.0	0.0	0.0	1.5	3.7	2.5	0.6	0.3	0.0	0.0	0.0	0.0	9.3	11.3-13.4
30.1-35.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.8	2.4	1.9	0.4	0.1	0.0	0.0	0.0	0.0	5.7	13.5-15.6
35.1-40.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	1.2	1.6	0.1	0.0	0.0	0.0	0.0	0.0	3.2	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.8	0.1	0.0	0.0	0.0	0.0	0.0	1.3	>17.9
CALM																	0.2	CALM
TOTAL	1.9	10.0	9.4	2.1	0.6	0.4	0.9	9.0	29.1	21.4	11.8	1.6	0.7	0.3	0.3	0.4	100.0	TOTAL
AV SPEED (MPH)	12.7	13.7	10.8	9.4	7.8	7.5	10.2	19.9	20.0	20.0	14.2	18.0	13.9	10.8	9.9	11.7	17.0	AV SPEED (MPH)
AV SPEED (M/SEC)	5.7	6.1	4.8	4.2	3.5	3.3	4.6	8.9	8.9	9.0	6.3	8.1	6.2	4.8	4.4	5.2	7.6	AV SPEED (M/SEC)

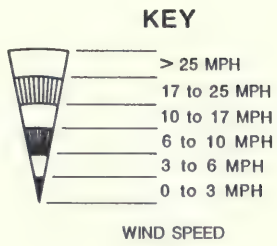
SOURCE: GEORESEARCH, INC.

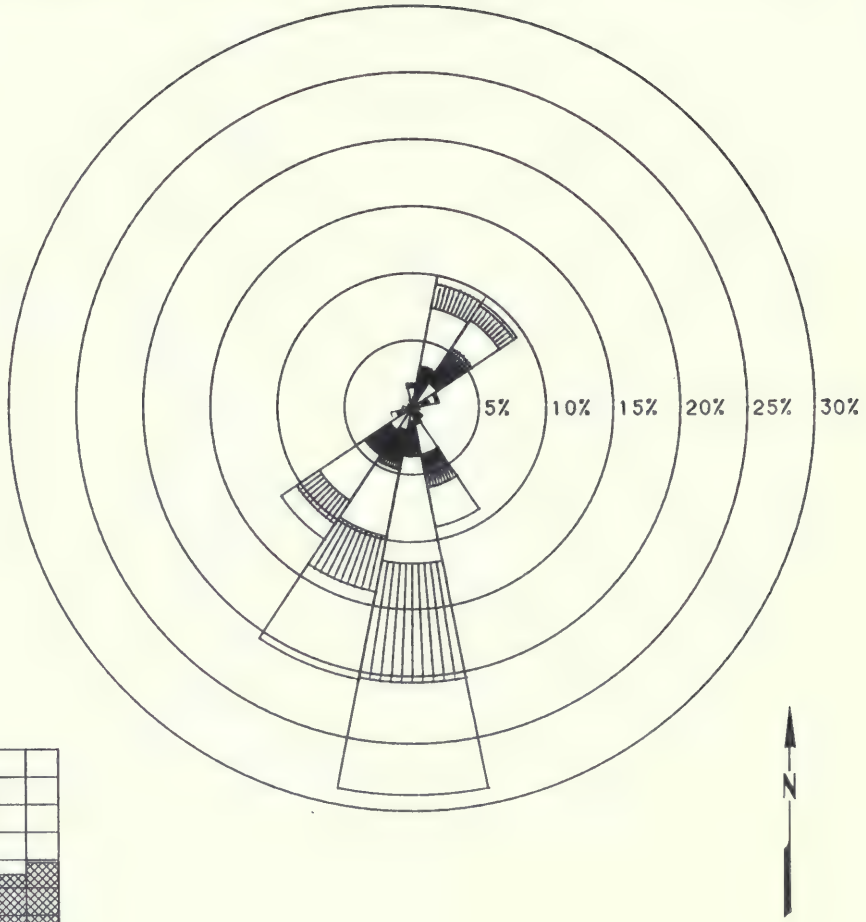
Figure IV - 12

Annual Wind Rose

MADISON COUNTY - NORRIS HILL

(1984 - 1986)





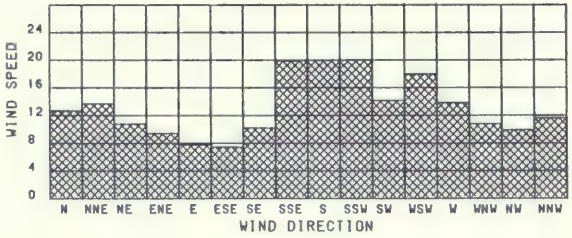


Table IV - 111

Coefficients of Weibull Distribution

MADISON COUNTY - NORRIS HILL

01/10/84 - 03/31/86

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	11.3258	2.3120
FEBRUARY	11.1553	2.0144
MARCH	8.6541	1.9453
APRIL	8.4476	2.0909
MAY	7.0567	2.0074
JUNE	6.5672	2.0709
JULY	5.7501	2.3289
AUGUST	6.4320	2.1890
SEPTEMBER	7.1492	1.9162
OCTOBER	10.5452	2.4754
NOVEMBER	8.9925	2.3193
DECEMBER	12.5081	1.9372
YEAR	8.4924	1.8549

SOURCE: GEORESEARCH, INC.

SUPERIOR NWS AIRPORT

MINERAL COUNTY

The Superior Airport is located 2 miles southeast of Superior at 47 10 48 N and 114 52 12 W (Site No. 78 on Map II-1). Elevation at the airport is 2,700 feet. Meteorological data were collected at this site for several years by the National Weather Service.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories.

The data set consists of summaries derived from hourly observations made from January 1, 1948, through November 30, 1953. The anemometer was mounted on a beacon tower at a height of 17.7 meters. The site is representative only of a restricted area along the Clark Fork.

Average monthly wind speeds varied from 4.5 miles per hour in December to 5.8 miles per hour in April, May, and August. Average annual wind speed was 5.1 miles per hour.

Average monthly wind power ranged from 11.0 watts/m² in December to 22.0 watts/m² in August. Average annual wind power was 16.0 watts/m².

Table IV - 112

Monthly Wind Speed Distribution

MINERAL COUNTY - SUPERIOR NWS AIRPORT

01/01/48 - 11/30/53

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	16.4	12.4	10.3	8.5	9.0	8.7	11.9	12.2	12.7	17.8	16.6	14.6	12.5	CALM (<0.5)
1.1- 3.1	15.4	17.0	15.6	12.2	11.6	15.4	15.3	12.7	14.3	16.0	16.9	18.6	15.0	0.5- 1.4
3.4- 5.4	37.7	35.7	35.0	35.8	34.6	34.3	32.7	32.7	33.3	35.0	36.3	37.7	35.0	1.5- 2.4 S
S 5.6- 7.6	15.3	17.6	17.4	18.6	20.1	18.3	16.3	15.4	17.7	14.8	15.0	15.3	16.8	2.5- 3.4 P
P 7.8- 9.8	8.1	9.3	10.6	11.5	12.4	12.1	10.6	11.4	10.5	8.5	8.4	7.0	10.1	3.5- 4.4 E
E 10.1-12.1	5.4	6.6	8.3	9.1	9.2	8.6	9.6	11.6	8.2	6.4	5.1	5.5	7.9	4.5- 5.4 E
E 12.3-14.3	0.9	1.0	1.5	2.1	1.4	1.3	1.5	1.9	1.5	0.8	0.7	0.8	1.3	5.5- 6.4 D
D 14.5-16.6	0.4	0.3	0.7	1.3	0.8	0.8	1.0	1.1	1.0	0.4	0.5	0.3	0.7	6.5- 7.4
16.8-18.8	0.3	0.1	0.3	0.4	0.7	0.4	0.7	0.8	0.5	0.3	0.1	0.1	0.4	7.5- 8.4 M
M 19.0-21.0	0.1	0.0	0.2	0.2	0.2	0.1	0.3	0.2	0.1	0.0	0.1	0.0	0.1	8.5- 9.4 E
I 21.3-23.3	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	9.5-10.4 T
L 23.5-25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5-11.4 E
E 25.7-27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	11.5-12.4 R
S 28.0-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5-13.4 S
/ 30.2-32.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5-14.4 /
H 32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5-15.4 S
O 34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	4.7	4.9	5.4	5.8	5.8	5.6	5.6	5.8	5.4	4.7	4.7	4.5	5.1	
AVERAGE SPEED (M/SEC)	2.1	2.2	2.4	2.6	2.6	2.5	2.5	2.6	2.4	2.1	2.1	2.0	2.3	
AVERAGE WIND POWER (WATTS/M**2)	12.0	12.0	16.0	21.0	20.0	17.0	20.0	22.0	19.0	13.0	13.0	11.0	16.0	

ANEMOMETER HEIGHT = 58.0 FEET = 17.7 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

MISSOULA HOERNER-WALDORF #1

MISSOULA COUNTY

The Hoerner-Waldorf #1 site is located about 12 miles northwest of Missoula at 46 57 03 N and 114 10 50 W (Site No. 81 on Map II-1). Elevation at the site is 3,139 feet. The site was established by Hoerner-Waldorf to monitor particulate concentrations in the air and meteorological conditions in the area.

Data gathering at the site commenced on July 1, 1977. Due to problems with the data set, only data from November 1, 1977, through March 31, 1982, were analyzed for this *Atlas*. The data set consists of hourly averages of wind speed and wind direction, obtained by manually reducing the data from stripchart records. Anemometer height was 10 meters.

Data recovery was good to excellent, ranging from 74.3 percent in January to 99.9 percent in March. Overall data recovery was 89.0 percent. Winds were monitored long enough to adequately represent the wind resource at this location. The data, however, are representative only of a limited area of the Missoula Valley near the site.

Average annual wind speed at this site was 5.1 miles per hour. Average monthly wind speeds varied from 3.8 miles per hour in December and January to 6.5 miles per hour in April.

Average monthly wind power ranged from 14.8 watts/m^2 in October to 45.4 watts/m^2 in April. Average annual wind power was 30.5 watts/m^2.

Table IV - 113

Monthly Wind Speed Distribution

MISSOULA COUNTY - MISSOULA HOERNER-WALDORF #1

11/01/77 - 03/31/82

SPEED / DIRECTION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	9.6	5.4	4.5	0.9	0.9	1.1	1.4	3.0	1.9	3.8	6.2	6.6	3.9
0.1-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7	1.5
1.1-2.0	15.4	8.4	5.3	3.2	2.4	2.5	3.5	5.6	5.9	7.1	10.9	10.0	6.8
2.1-3.0	26.3	21.7	16.6	12.8	11.9	12.3	15.3	15.4	16.2	23.8	25.0	17.2	18.0
3.1-4.0	17.2	22.5	20.1	18.3	18.4	20.1	21.3	19.0	23.3	27.2	20.0	15.4	20.0
4.1-5.0	9.7	11.9	12.4	13.9	13.4	15.2	14.7	15.3	14.8	13.8	11.3	9.9	12.9
5.1-6.0	5.4	7.7	7.1	8.7	8.6	10.8	8.3	7.6	8.8	6.9	6.7	5.3	7.6
6.1-7.0	2.5	4.0	4.4	5.7	6.8	6.6	5.2	5.5	4.9	3.7	3.4	2.9	4.6
7.1-8.0	2.4	2.5	4.1	5.0	6.1	4.7	4.3	3.2	4.3	2.7	2.7	2.5	3.7
8.1-9.0	1.4	2.2	3.9	3.8	5.3	4.2	3.2	3.8	3.3	2.1	1.3	2.6	3.1
9.1-10.0	0.9	1.5	3.0	3.8	4.7	3.3	3.0	3.2	3.0	1.3	1.4	1.4	2.5
10.1-11.0	1.2	1.5	3.5	3.6	4.9	3.4	3.4	3.3	2.4	1.4	1.1	1.7	2.6
11.1-12.0	1.3	1.2	2.4	3.8	2.6	2.8	2.5	2.7	2.5	1.0	1.0	1.1	2.0
12.1-13.0	0.8	0.9	2.0	2.8	3.5	3.3	2.9	2.5	2.2	1.0	1.0	1.3	2.0
13.1-14.0	0.5	0.8	2.3	2.8	3.0	2.6	2.1	2.2	1.4	1.0	1.0	1.0	1.7
14.1-15.0	0.4	1.0	1.6	2.1	1.8	1.7	2.5	2.0	1.3	0.9	0.8	1.2	1.4
15.1-16.0	0.4	1.1	2.1	2.2	1.7	1.3	2.0	1.6	1.8	0.3	1.0	1.1	1.4
16.1-17.0	0.6	0.9	1.1	2.0	1.0	0.9	1.4	1.0	0.7	0.5	1.3	0.6	1.0
17.1-18.0	0.6	0.7	0.8	1.3	1.4	1.0	1.2	1.3	0.3	0.5	0.8	0.8	0.9
18.1-19.0	0.9	0.5	0.8	1.2	0.4	1.0	0.8	0.7	0.2	0.4	0.5	0.5	0.7
19.1-20.0	0.4	0.1	0.5	0.7	0.5	0.6	0.3	0.4	0.2	0.2	0.6	0.3	0.4
20.1-25.0	1.6	3.2	1.6	1.3	0.4	0.6	0.9	0.8	0.4	0.5	1.7	0.8	1.2
25.1-30.0	0.2	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1
30.1-35.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	3.8	4.7	5.5	6.5	6.2	5.9	5.8	5.6	5.0	4.0	4.4	3.8	5.1
AVERAGE SPEED (M/SEC)	1.7	2.1	2.5	2.9	2.8	2.7	2.6	2.5	2.2	1.8	2.0	1.7	2.3
AVERAGE WIND POWER (WATTS/M**2)	25.7	36.5	35.6	45.4	32.5	31.6	35.6	30.4	21.9	14.8	29.9	22.4	30.5
PERCENT DATA RECOVERY	74.3	86.9	99.9	99.0	92.7	82.0	99.1	98.0	74.4	74.6	98.9	87.8	89.0

SPEED / DIRECTION

CALM	
0.1- 0.4	
0.5- 0.9	S
1.0- 1.3	P
1.4- 1.8	E
1.9- 2.2	E
2.3- 2.7	D
2.8- 3.1	
3.2- 3.6	M
3.7- 4.0	E
4.1- 4.5	T
4.6- 4.9	E
5.0- 5.4	R
5.5- 5.8	S
5.9- 6.3	/
6.4- 6.7	S
6.8- 7.2	E
7.3- 7.6	C
7.7- 8.0	O
8.1- 8.5	N
8.6- 8.9	D
9,0-11.2	
11.3-13.4	
13.5-15.6	
15.7-17.9	
>17.9	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 34442
PERCENTAGE DATA RECOVERY = 89.0

SOURCE: GEORESEARCH, INC.

MISSOULA NWS AIRPORT

MISSOULA COUNTY

The Missoula NWS Airport is located approximately 5 miles northwest of Missoula at 46 55 40 N and 114 05 50 W (Site No. 84 on Map II-1). Elevation at the airport is 3,214 feet. Meteorological data have been collected here for many years by the National Weather Service.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in anemometer height and reporting interval, the data set was broken into three periods for analysis: January 1, 1948, through April 3, 1958; April 4, 1958, through December 31, 1964; and January 1, 1965, through December 31, 1978. Only data from the most recent period were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Missoula consists of summaries of observations made every third hour from January 1, 1965, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 6.1 meters. Due to the complex terrain, the data are representative only of the immediate area.

Average annual wind speed at the site was 6.3 miles per hour. Average monthly wind speeds ranged from 4.9 miles per hour in October and November to 7.6 miles per hour in April.

Average annual wind power was 43.0 watts/m^2. Average monthly wind power ranged from 27.0 watts/m^2 in October to 65.0 watts/m^2 in April.

Table IV - 114

Monthly Wind Speed Distribution

MISSOULA COUNTY - MISSOULA NWS AIRPORT

01/01/65 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	21.1	20.4	13.6	11.3	11.8	11.4	14.0	16.2	18.8	22.8	23.0	22.7	17.2	CALM (<0.5)
1.1- 3.1	2.2	2.4	2.2	1.8	1.7	1.6	1.6	1.8	2.4	3.3	3.0	3.5	2.3	0.5- 1.4
3.4- 5.4	33.6	35.1	30.2	27.1	26.6	29.0	29.5	30.7	33.3	36.6	35.8	34.4	31.8	1.5- 2.4 S
S 5.6- 7.6	18.0	18.9	20.2	18.3	20.4	21.6	20.4	19.4	18.5	17.6	18.7	18.5	19.2	2.5- 3.4 P
P 7.8- 9.8	9.3	8.8	10.9	12.6	12.1	11.5	11.5	10.6	9.8	7.6	7.7	7.1	9.9	3.5- 4.4 E
E 10.1-12.1	5.0	4.4	7.2	8.7	9.1	8.5	7.7	7.1	5.8	4.0	4.2	5.0	6.4	4.5- 5.4 E
E 12.3-14.3	3.8	3.6	5.4	6.5	6.4	6.0	5.5	5.5	4.6	3.1	2.8	3.5	4.7	5.5- 6.4 D
D 14.5-16.6	2.3	2.9	4.6	5.4	5.3	4.6	4.3	3.5	3.4	2.5	2.2	2.3	3.6	6.5- 7.4
16.8-18.8	1.8	1.8	2.8	4.6	3.7	3.5	3.2	2.7	1.8	1.6	1.2	1.4	2.5	7.5- 8.4 M
M 19.0-21.0	1.4	1.0	1.4	2.0	2.0	1.4	1.5	1.6	0.8	0.5	0.7	0.9	1.3	8.5- 9.4 E
I 21.3-23.3	0.6	0.4	1.1	1.0	0.6	0.5	0.6	0.7	0.5	0.2	0.4	0.3	0.6	9.5-10.4 T
L 23.5-25.5	0.4	0.3	0.2	0.3	0.1	0.2	0.1	0.2	0.1	0.0	0.1	0.1	0.2	10.5-11.4 E
E 25.7-27.7	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	11.5-12.4 R
S 28.0-30.0	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.1	12.5-13.4 S
/ 30.2-32.2	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	13.5-14.4 /
H 32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5-15.4 S
O 34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	5.6	5.6	6.9	7.6	7.4	7.2	6.7	6.5	5.8	4.9	4.9	5.1	6.3	
AVERAGE SPEED (M/SEC)	2.5	2.5	3.1	3.4	3.3	3.2	3.0	2.9	2.6	2.2	2.2	2.3	2.8	
AVERAGE WIND POWER (WATTS/M**2)	44.0	35.0	52.0	65.0	55.0	50.0	46.0	45.0	34.0	27.0	29.0	31.0	43.0	

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

MISSOULA UNIVERSITY OF MONTANA

MISSOULA COUNTY

The University of Montana site was located on the northeastern corner of the University of Montana campus near the mouth of Hellgate Canyon at 46 51 50 N and 113 58 40 W (Site No. 88 on Map II-1). Elevation at the site was 3,198 feet. The site was established by the Montana Air Quality Bureau to monitor wind speed and wind direction as part of the Montana Air Pollution Study.

Wind data collected from May 1, 1978, through March 17, 1980, were available for analysis. The data consist of hourly averages of wind speed and wind direction, obtained by manually reducing information from strip-chart records. The data were gathered by a Climatronics electronic anemometer and wind vane on a 10-meter tower.

Winds were monitored long enough to adequately represent the wind resource at this location. The site, however, is representative only of a limited area near the mouth of Hellgate Canyon. Data recovery, which for the entire period was 83.4 percent, ranged from 33.9 percent in November to 100.0 percent in September.

Average annual wind speed at the site was 6.3 miles per hour. Average monthly wind speeds varied from 5.5 miles per hour in July to 7.5 miles per hour in December.

Average annual wind power was 48.8 watts/m^2. Average monthly wind power ranged from 19.5 watts/m^2 in September to 129.7 watts/m^2 in February.

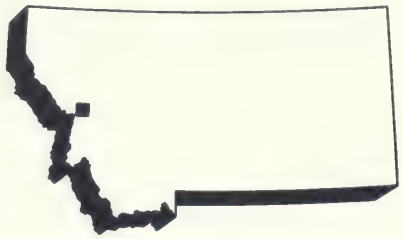


Table IV - 115

Monthly Wind Speed Distribution

MISSOULA COUNTY - MISSOULA UNIVERSITY OF MONTANA

05/01/78 - 03/17/80

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	CALM
0.1-1.0	0.0	0.8	0.8	0.0	0.1	0.0	0.1	0.0	0.1	0.2	1.6	1.5	0.4	0.1- 0.4
1.1-2.0	5.8	7.6	5.1	1.6	5.1	4.4	4.3	3.6	3.5	4.8	12.3	6.0	5.1	0.5- 0.9
2.1-3.0	14.7	16.2	11.3	6.5	15.1	14.0	15.9	16.0	16.8	16.4	16.6	10.5	14.8	1.0- 1.3
3.1-4.0	19.4	16.8	16.7	14.2	13.0	16.6	20.4	19.0	17.6	20.0	15.6	12.3	17.1	1.4- 1.8
4.1-5.0	12.7	10.9	9.6	9.9	10.0	13.1	13.4	12.4	10.5	9.5	10.2	9.9	11.2	1.9- 2.2
5.1-6.0	6.8	6.5	9.4	11.9	8.6	10.2	10.0	9.2	9.0	7.8	8.2	6.6	8.5	2.3- 2.7
6.1-7.0	4.2	4.7	8.2	10.1	7.7	7.1	6.2	6.8	7.9	5.5	6.6	4.9	6.4	2.8- 3.1
7.1-8.0	3.8	5.2	6.9	7.6	7.1	8.0	5.5	7.3	6.5	6.5	4.3	6.9	6.4	3.2- 3.6
8.1-9.0	4.1	4.5	7.1	9.4	6.4	5.7	5.7	5.5	6.2	6.4	4.5	5.8	5.8	3.7- 4.0
9.1-10.0	3.8	3.4	4.3	5.2	6.0	5.7	5.7	4.4	6.1	5.1	3.9	3.8	4.9	4.1- 4.5
10.1-11.0	3.7	3.2	4.0	6.3	5.4	4.8	4.8	5.6	4.9	5.2	4.5	5.0	4.8	4.6- 4.9
11.1-12.0	3.2	1.7	2.5	4.0	5.1	2.7	2.0	2.3	4.7	4.5	2.0	4.1	3.3	5.0- 5.4
12.1-13.0	4.5	2.8	2.8	4.0	3.3	2.8	0.7	1.9	3.1	2.4	1.6	4.5	2.8	5.5- 5.8
13.1-14.0	2.6	2.1	1.1	2.5	2.4	1.0	1.0	1.2	1.6	2.0	1.0	4.1	1.9	5.9- 6.3
14.1-15.0	1.6	1.7	1.4	1.3	1.0	1.1	0.7	1.0	0.5	0.9	0.4	2.8	1.2	6.4- 6.7
15.1-16.0	1.2	0.9	1.2	1.8	1.3	1.3	0.7	0.5	0.4	1.1	1.2	2.8	1.2	6.8- 7.2
16.1-17.0	0.6	0.3	0.9	0.7	0.3	0.5	0.5	0.4	0.1	0.3	1.0	2.1	0.6	7.3- 7.6
17.1-18.0	1.4	0.6	0.5	0.0	0.9	0.5	0.8	0.6	0.4	0.4	0.6	1.6	0.7	7.7- 8.0
18.1-19.0	1.3	1.0	0.5	0.4	0.5	0.3	0.1	0.5	0.1	0.1	0.6	1.2	0.5	8.1- 8.5
19.1-20.0	0.3	0.2	0.3	0.7	0.3	0.1	0.3	0.5	0.0	0.0	0.8	1.2	0.3	8.6- 8.9
20.1-25.0	3.2	2.7	2.3	1.8	0.3	0.0	0.9	1.0	0.0	0.5	1.8	1.4	1.1	9,0-11.2
25.1-30.0	0.9	4.2	1.7	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.2	0.6	0.7	11.3-13.4
30.1-35.0	0.0	1.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	13.5-15.6
35.1-40.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	>17.9
AVERAGE SPEED (MPH)	6.7	7.4	7.1	7.0	6.3	5.8	5.5	5.8	5.6	5.7	5.6	7.5	6.3	
AVERAGE SPEED (M/SEC)	3.0	3.3	3.2	3.1	2.8	2.6	2.5	2.6	2.5	2.6	2.5	3.4	2.8	
AVERAGE WIND POWER (WATTS/M**2)	60.9	129.7	83.8	40.7	30.0	22.6	24.0	28.2	19.5	26.9	39.6	122.4	48.8	
PERCENT DATA RECOVERY	82.8	92.9	56.3	61.8	99.0	99.4	99.1	93.4	100.0	99.6	33.9	82.7	83.4	

SPEED

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 14136
PERCENTAGE DATA RECOVERY = 83.4

SOURCE: GEORESEARCH, INC.

LIVINGSTON CANDIDATE WIND TURBINE SITE

PARK COUNTY

The Livingston Candidate Wind Turbine site is located approximately 2 miles northeast of Livingston, and just east of the old airport, at 45 40 27 N and 110 30 01 W (Site No. 95 on Map II-1). Elevation at the site is 4,658 feet.

The site is located in the Yellowstone River Valley just north of the Absaroka Mountains. Most of the land in the valley is privately owned, although there are a few sections of publicly owned land in the region. Much of the privately owned land has been leased for wind energy use. Land in the mountains is controlled predominantly by the U.S. Forest Service. Electrical service in the area is provided by the Montana Power Company and by the Park Electric Cooperative. The only commercial airport in the area is 4 miles northeast of the site.

This site was established by the U.S. Department of Energy as part of a federal wind energy program. The intent of the program was to provide information on wind characteristics to those involved in the design, evaluation, and operation of wind energy systems. The Bonneville Power Administration assumed responsibility for operating the site in October 1982 through June 1983. Little data were recovered during that period because of equipment failures. Montana DNRC in 1986 resumed monitoring at this site in a study of wind shear.

Wind data from September 1, 1980, through June 30, 1982, were available for analysis. The data set consists of hourly averages of wind speed and wind direction at three heights: 9.1, 30.0, and 45.7 meters above ground level. Data recovery ranged from 49.2 percent in May to 99.5 percent in October. Overall data recovery at 9.1 meters was 78.8 percent. The percentage of data recovery was different at the different levels. (BPA is gathering data only at 15.2 meters and 45.7 meters.)

This monitoring period was long enough to adequately represent the wind resource at the location. Because the terrain in the area is complex, the data are representative only of a limited area in the Yellowstone River Valley near Livingston.

At 9.1 meters above ground level, average annual wind speed was 15.6 miles per hour. Average monthly wind speeds ranged from 9.5 miles per hour in August to 23.3 miles per hour in December. Average annual wind power at this height was 494.4 watts/m^2. Average monthly wind power varied from 95.1 watts/m^2 in August to 1,260.1 watts/m^2 in December. (The average speed and power for February may be low, due to malfunctioning equipment.)

At 30 meters above ground level, the average annual wind speed was 18.1 miles per hour. Average monthly wind speeds at this height ranged from 11.1 miles per hour in August to 26.2 miles per hour in December. Average annual wind power at this height was 738.4 watts/m^2. Average monthly wind power varied from 150.0 watts/m^2 in August to 1760.2 watts/m^2 in December.

At 45.7 meters above ground level, average annual wind speed was 19.5 miles per hour. Average monthly wind speeds ranged from 13.2 miles per hour in August to 27.4 miles per hour in December. Average annual wind power at this height was 876.4 watts/m^2. Average monthly wind power ranged from 196.3 watts/m^2 in August to 2,101.7 watts/m^2 in February.

Average seasonal wind speeds at 9.1 meters were 11.2 miles per hour in summer, 12.8 miles per hour in spring, 15.4 miles per hour in autumn, and 20.8 miles per hour in winter.

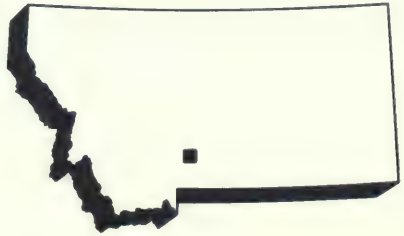


Table IV - 116

Monthly Wind Speed Distribution

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

09/01/80 - 06/30/82

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
	CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CALM	
	0.1-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1-0.4	
	1.1-2.0	1.0	11.5	4.1	1.3	0.5	0.4	0.4	1.4	0.3	0.0	0.3	0.1	1.8	0.5-0.9	S
S	2.1-3.0	2.5	1.3	3.7	4.5	3.1	3.3	2.6	6.4	4.8	2.2	3.5	1.3	3.1	1.0-1.3	P
P	3.1-4.0	5.8	2.5	6.7	5.8	7.2	5.0	8.3	10.5	8.4	5.4	3.2	2.0	5.5	1.4-1.8	E
E	4.1-5.0	4.9	2.9	7.0	5.2	7.9	8.5	7.7	10.6	6.8	5.3	2.9	2.4	5.6	1.9-2.2	E
E	5.1-6.0	4.8	1.2	4.2	4.7	8.2	7.7	8.2	8.3	8.0	6.2	2.2	3.2	5.2	2.3-2.7	D
D	6.1-7.0	3.8	1.7	4.9	4.7	6.8	6.1	5.6	7.6	7.1	4.4	1.9	2.1	4.4	2.8-3.1	
	7.1-8.0	1.9	2.6	6.5	4.1	8.9	5.2	5.6	5.3	4.9	4.1	2.8	2.8	4.3	3.2-3.6	M
M	8.1-9.0	4.3	1.2	3.9	3.8	6.3	5.4	5.2	6.0	3.9	3.6	2.0	2.9	3.8	3.7-4.0	E
I	9.1-10.0	2.1	2.0	4.8	3.6	3.7	5.8	5.7	4.9	5.0	3.3	2.1	2.7	3.6	4.1-4.5	T
L	10.1-11.0	2.9	1.6	3.8	2.7	4.6	5.7	3.4	3.9	5.1	4.5	3.1	1.5	3.5	4.6-4.9	E
E	11.1-12.0	2.7	2.2	3.6	2.7	4.6	5.3	4.2	4.2	5.3	4.2	2.9	2.5	3.6	5.0-5.4	R
S	12.1-13.0	3.1	2.7	3.8	2.4	4.0	3.6	3.3	4.8	5.6	3.2	4.0	2.7	3.6	5.5-5.8	S
/	13.1-14.0	4.1	2.2	2.8	2.7	3.4	3.3	2.3	3.7	4.8	3.2	3.7	2.7	3.3	5.9-6.3	/
H	14.1-15.0	4.6	2.0	4.7	4.2	2.6	3.9	3.3	2.4	4.2	4.3	3.6	2.7	3.6	6.4-6.7	S
O	15.1-16.0	3.5	1.5	2.8	4.0	4.2	3.0	3.1	2.2	3.3	2.9	2.6	3.3	3.0	6.8-7.2	E
U	16.1-17.0	3.3	2.6	2.9	3.8	3.1	3.9	5.6	3.8	3.4	4.2	3.1	2.8	3.5	7.3-7.6	C
R	17.1-18.0	3.2	2.7	2.9	4.5	3.1	3.2	3.7	2.6	2.5	3.4	3.7	3.0	3.2	7.7-8.0	O
	18.1-19.0	3.2	2.2	3.0	3.7	2.6	3.6	4.3	3.1	2.8	3.3	4.7	2.2	3.2	8.1-8.5	N
	19.1-20.0	3.3	3.2	2.7	4.4	3.1	3.5	4.3	2.2	1.8	3.8	3.8	3.0	3.2	8.6-8.9	D
	20.1-25.0	11.1	12.1	13.5	13.2	9.7	8.6	9.4	4.5	7.1	14.7	15.5	11.8	11.3	9.0-11.2	
	25.1-30.0	9.1	9.6	4.9	6.9	2.0	2.8	2.7	1.8	3.3	8.8	12.1	10.8	6.9	11.3-13.4	
	30.1-35.0	4.4	10.7	1.9	4.6	0.0	1.4	0.4	0.0	1.1	2.7	7.6	9.9	4.3	13.5-15.6	
	35.1-40.0	3.0	8.9	1.1	1.5	0.0	0.4	0.7	0.0	0.7	1.4	5.2	9.4	3.2	15.7-17.9	
	>40.0	7.4	8.9	0.0	0.9	0.0	0.0	0.1	0.0	0.0	1.0	3.5	12.3	3.4	>17.9	
AVERAGE SPEED (MPH)		17.7	20.7	12.6	14.8	11.0	11.8	11.9	9.5	11.3	15.1	19.3	23.3	15.6		
AVERAGE SPEED (M/SEC)		7.9	9.3	5.7	6.6	4.9	5.3	5.3	4.3	5.1	6.7	8.6	10.4	7.0		
AVERAGE WIND POWER (WATTS/M**2)		733.9	1044.5	241.0	364.6	132.4	171.8	176.1	95.1	160.5	358.3	1095.8	1260.1	494.4		
PERCENT DATA RECOVERY		70.7	89.4	63.3	54.2	49.2	69.2	98.9	98.9	84.7	99.5	97.6	91.1	78.8		

ANEMOMETER HEIGHT = 9.1 METERS = 30 FEET
NUMBER OF OBSERVATIONS = 12638
PERCENTAGE DATA RECOVERY = 78.8

SOURCE: GEORESEARCH, INC.

Table IV - 117

Monthly Average Wind Speed and Wind Power Density (30 Meters)

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

09/01/80 - 06/30/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
AVERAGE SPEED (MPH)	20.0	25.4	19.2	16.7	12.1	13.6	13.8	11.1	13.0	17.3	22.4	26.2	18.1
AVERAGE SPEED (M/SEC)	8.9	11.3	8.6	7.5	5.4	6.1	6.2	5.0	5.8	7.7	10.0	11.7	8.1
AVERAGE WIND POWER (WATTS/M**3)	984.3	1740.4	739.2	512.2	180.3	254.5	267.7	150.0	245.7	526.3	1059.5	1760.2	738.4
PERCENT DATA RECOVERY	70.6	75.4	54.8	54.2	49.1	69.0	98.8	98.9	84.6	98.8	94.3	80.4	75.5

SOURCE: GEORESEARCH, INC.

Table IV - 118

Monthly Average Wind Speed and Wind Power Density (45.7 Meters)

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

09/01/80 - 06/30/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
AVERAGE SPEED (MPH)	22.7	26.5	20.5	18.2	14.4	15.3	15.7	13.2	14.7	19.0	22.8	27.4	19.5
AVERAGE SPEED (M/SEC)	10.2	11.9	9.2	8.1	6.4	6.8	7.0	5.9	6.6	8.5	10.2	12.2	8.7
AVERAGE WIND POWER (WATTS/M**3)	1592.4	2101.7	916.4	601.7	243.1	323.3	328.4	196.3	309.9	670.4	1068.9	2077.9	876.4
PERCENT DATA RECOVERY	45.7	71.4	55.2	54.3	49.2	69.2	98.9	98.9	84.7	99.4	83.9	77.8	71.8

SOURCE: GEORESEARCH, INC.

Table IV - 119

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

(WINTER)

09/01/80 - 06/30/82

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	4.6	5.9	9.2	5.2	5.2	3.9	5.9	6.5	6.5	3.9	11.8	5.2	9.8	3.9	12.4	19.8	8.8
	2	0.0	4.0	5.4	8.7	4.0	5.4	4.7	7.4	6.7	4.0	4.7	10.7	6.7	10.7	6.7	10.1	20.4	9.1
	3	0.0	2.6	5.3	6.6	4.6	5.3	6.6	4.6	7.3	4.0	7.9	11.3	7.3	7.9	9.9	8.6	20.8	9.3
	4	0.0	4.0	3.3	7.3	2.7	4.7	3.3	6.7	9.3	6.7	6.0	12.0	7.3	9.3	7.3	10.0	21.0	9.4
	5	0.0	3.3	4.0	6.0	5.3	5.3	4.7	4.7	3.3	9.3	6.7	12.0	9.3	8.7	6.7	10.7	21.2	9.5
	6	0.0	2.7	4.7	6.1	3.4	7.4	4.1	5.4	5.4	4.7	4.7	12.8	10.8	7.4	8.1	12.2	21.6	9.6
	7	0.0	3.4	3.4	7.4	6.7	4.7	2.7	5.4	4.0	6.7	2.7	9.4	16.8	8.1	8.1	10.7	22.0	9.8
	8	0.0	3.4	5.4	4.0	6.7	2.7	6.7	4.0	5.4	4.0	5.4	10.7	10.7	9.4	8.1	13.4	22.5	10.1
H	9	0.0	3.4	5.4	3.4	6.0	4.7	4.0	3.4	6.0	5.4	2.7	10.7	15.4	9.4	8.1	12.1	23.0	10.3
	10	0.0	4.7	4.0	3.4	3.4	5.4	4.0	4.0	6.7	4.7	3.4	8.7	15.4	10.7	8.1	13.4	23.4	10.5
O	11	0.0	4.1	3.4	4.1	5.4	4.1	3.4	6.1	4.7	3.4	5.4	8.1	14.9	9.5	8.1	15.5	23.8	10.6
	12	0.0	6.1	4.8	5.4	3.4	2.7	2.7	4.8	4.8	4.8	4.8	9.5	12.9	11.6	8.2	13.6	22.8	10.2
U	13	0.0	5.4	2.0	6.8	4.1	3.4	4.1	4.1	3.4	3.4	6.1	14.9	10.8	9.5	13.5	8.8	22.6	10.1
	14	0.0	5.4	1.3	6.7	5.4	4.0	4.7	5.4	2.0	5.4	6.0	14.8	15.4	8.7	7.4	7.4	21.2	9.5
R	15	0.0	5.3	3.9	5.3	3.9	5.3	2.6	6.6	3.3	5.9	8.6	19.7	7.2	6.6	7.2	8.6	20.4	9.1
	16	0.0	5.9	4.6	2.6	3.9	2.6	7.2	4.6	7.2	8.5	7.8	15.7	5.9	11.8	5.9	5.9	20.1	9.0
	17	0.0	5.2	3.3	5.2	3.9	4.6	5.2	10.5	7.8	5.9	8.5	11.1	7.8	8.5	6.5	5.9	19.3	8.6
	18	0.0	3.9	3.9	5.2	5.2	6.5	6.5	7.8	10.5	4.6	5.2	13.1	4.6	10.5	4.6	7.8	19.1	8.5
	19	0.0	3.3	6.5	7.2	5.2	8.5	2.0	5.9	8.5	9.2	5.9	7.8	7.2	7.2	9.8	5.9	19.0	8.5
	20	0.0	3.3	5.9	9.2	5.3	7.9	6.6	5.3	4.6	7.9	7.2	7.9	8.6	6.6	5.9	7.9	18.7	8.4
	21	0.0	4.0	7.3	5.3	8.6	4.0	3.3	6.0	6.6	7.9	4.6	13.9	8.6	5.3	5.3	9.3	19.2	8.6
	22	0.0	2.7	5.3	10.0	8.0	4.7	2.0	6.0	3.3	5.3	9.3	12.0	11.3	5.3	5.3	9.3	19.5	8.7
	23	0.0	5.3	8.6	7.9	4.0	6.6	4.0	6.0	4.6	6.6	3.3	12.6	9.9	5.3	7.3	7.9	19.1	8.5
	24	0.0	3.9	9.9	7.9	3.9	5.3	5.3	7.2	5.9	5.3	4.6	9.2	8.6	7.9	7.9	7.2	19.0	8.5
ALL HOURS		0.0	4.2	4.9	6.3	4.9	5.0	4.4	5.7	5.8	5.8	5.7	11.7	9.9	8.6	7.4	9.8	20.8	9.3

SOURCE: GEORESEARCH, INC.

Table IV - 120

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

(SPRING)

09/01/80 - 06/30/82

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
		WIND SPEED (METERS/SECOND)															AV SPEED	AV SPEED
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	(MPH)	(M/SEC)
	1	0.0	2.9	19.4	15.5	16.5	2.9	4.9	2.9	7.8	7.8	4.9	9.7	1.9	1.9	1.0	0.0	10.7	4.8
	2	0.0	1.9	19.2	12.5	15.4	9.6	4.8	5.8	7.7	5.8	2.9	7.7	4.8	1.0	1.0	0.0	10.9	4.9
	3	0.0	3.9	19.4	12.6	8.7	7.8	5.8	7.8	6.8	6.8	4.9	6.8	4.9	2.9	1.0	0.0	11.4	5.1
	4	0.0	2.9	21.6	7.8	8.8	6.9	12.7	2.9	12.7	6.9	2.0	8.8	2.0	2.9	1.0	0.0	11.4	5.1
	5	0.0	4.9	14.6	8.7	10.7	12.6	6.8	2.9	9.7	8.7	7.8	6.8	1.0	4.9	0.0	0.0	11.7	5.2
	6	0.0	4.8	12.4	14.3	17.1	5.7	5.7	2.9	8.6	3.8	10.5	8.6	2.9	1.0	1.0	1.0	11.6	5.2
	7	0.0	5.8	12.5	17.3	5.8	11.5	5.8	4.8	3.8	8.7	6.7	8.7	5.8	1.9	1.0	0.0	11.7	5.2
	8	0.0	5.8	10.7	12.6	11.7	8.7	4.9	8.7	2.9	5.8	4.9	14.6	4.9	2.9	1.0	0.0	12.5	5.6
H	9	0.0	1.0	9.9	11.9	12.9	10.9	3.0	7.9	4.0	5.9	4.0	16.8	6.9	4.0	1.0	0.0	13.8	6.2
	10	0.0	2.0	5.9	13.7	8.8	9.8	3.9	7.8	8.8	3.9	6.9	14.7	7.8	4.9	1.0	0.0	14.5	6.5
O	11	0.0	1.0	6.1	13.1	12.1	6.1	5.1	5.1	6.1	5.1	6.1	19.2	11.1	3.0	0.0	1.0	15.1	6.7
	12	0.0	2.0	7.1	10.2	10.2	10.2	6.1	8.2	5.1	5.1	8.2	16.3	8.2	1.0	2.0	0.0	14.2	6.3
U	13	0.0	1.0	4.1	11.2	11.2	9.2	2.0	8.2	13.3	5.1	6.1	15.3	11.2	1.0	1.0	0.0	14.7	6.6
	14	0.0	0.0	2.0	11.1	12.1	5.1	10.1	2.0	11.1	6.1	12.1	17.2	6.1	4.0	1.0	0.0	15.4	6.9
R	15	0.0	1.0	2.9	7.8	8.8	9.8	8.8	4.9	5.9	10.8	12.7	17.6	4.9	2.9	1.0	0.0	15.3	6.8
	16	0.0	0.0	1.0	6.8	9.7	12.6	10.7	9.7	6.8	7.8	9.7	17.5	1.9	4.9	1.0	0.0	15.1	6.8
	17	0.0	1.0	3.8	7.7	7.7	6.7	6.7	11.5	11.5	9.6	12.5	13.5	3.8	1.9	1.0	1.0	15.0	6.7
	18	0.0	0.0	3.9	10.7	10.7	8.7	10.7	8.7	11.7	7.8	4.9	13.6	4.9	1.9	1.0	1.0	14.3	6.4
	19	0.0	0.0	4.9	10.7	13.6	8.7	13.6	10.7	5.8	7.8	5.8	11.7	4.9	0.0	1.0	1.0	13.3	6.0
	20	0.0	0.0	3.9	13.7	17.6	9.8	11.8	8.8	5.9	10.8	2.0	9.8	2.9	1.0	1.0	1.0	12.6	5.6
	21	0.0	1.9	12.5	14.4	14.4	7.7	10.6	6.7	6.7	7.7	4.8	7.7	2.9	0.0	1.0	1.0	11.4	5.1
	22	0.0	1.9	8.7	19.4	13.6	9.7	9.7	6.8	8.7	1.0	5.8	10.7	1.9	1.0	1.0	0.0	11.1	5.0
	23	0.0	1.9	19.4	15.5	12.6	9.7	7.8	1.0	6.8	5.8	3.9	12.6	1.9	1.0	0.0	0.0	10.5	4.7
	24	0.0	3.8	21.2	15.4	13.5	7.7	3.8	5.8	1.9	6.7	4.8	9.6	3.8	1.0	1.0	0.0	10.5	4.7
ALL HOURS		0.0	2.2	10.3	12.3	11.9	8.7	7.3	6.4	7.5	6.7	6.4	12.3	4.7	2.2	0.9	0.3	12.8	5.7

SOURCE: GEORESEARCH, INC.

Table IV - 121

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

(SUMMER)

09/01/80 - 06/30/82

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)																
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	0.0	15.5	20.4	15.5	10.7	7.8	10.7	3.9	5.8	7.8	1.0	0.0	1.0	0.0	0.0	9.4	4.2
	2	0.0	1.0	23.3	20.4	10.7	9.7	10.7	6.8	2.9	3.9	4.9	4.9	1.0	0.0	0.0	0.0	8.7	3.9
	3	0.0	1.0	21.4	28.2	12.6	5.8	7.8	3.9	7.8	3.9	3.9	1.9	1.9	0.0	0.0	0.0	8.4	3.8
	4	0.0	0.0	34.0	20.4	8.7	7.8	6.8	5.8	4.9	0.0	3.9	3.9	3.9	0.0	0.0	0.0	8.2	3.6
	5	0.0	2.9	28.2	24.3	4.9	11.7	4.9	4.9	1.9	3.9	5.8	4.9	1.9	0.0	0.0	0.0	8.3	3.7
	6	0.0	5.8	22.3	23.3	9.7	8.7	9.7	1.9	3.9	2.9	2.9	5.8	1.9	1.0	0.0	0.0	8.5	3.8
	7	0.0	2.9	27.2	22.3	9.7	4.9	7.8	3.9	4.9	5.8	1.9	6.8	0.0	1.0	1.0	0.0	8.7	3.9
	8	0.0	2.9	27.2	19.4	5.8	8.7	9.7	3.9	2.9	7.8	3.9	3.9	2.9	0.0	1.0	0.0	9.0	4.0
H	9	0.0	0.0	22.3	13.6	14.6	6.8	4.9	5.8	7.8	9.7	4.9	5.8	2.9	1.0	0.0	0.0	10.3	4.6
	10	0.0	0.0	12.6	22.3	8.7	13.6	5.8	5.8	1.0	6.8	9.7	12.6	0.0	1.0	0.0	0.0	11.0	4.9
O	11	0.0	0.0	7.8	18.4	15.5	10.7	4.9	7.8	7.8	6.8	8.7	8.7	1.0	0.0	1.9	0.0	11.5	5.2
	12	0.0	0.0	4.0	20.0	14.0	14.0	8.0	4.0	5.0	7.0	12.0	9.0	1.0	1.0	1.0	0.0	12.0	5.4
U	13	0.0	0.0	1.0	20.2	16.2	10.1	10.1	5.1	9.1	5.1	7.1	12.1	1.0	2.0	0.0	1.0	12.4	5.5
	14	0.0	0.0	2.0	11.9	7.9	11.9	11.9	8.9	9.9	9.9	5.0	15.8	3.0	0.0	2.0	0.0	14.0	6.3
R	15	0.0	0.0	3.0	8.9	9.9	11.9	8.9	4.0	5.9	16.8	7.9	15.8	4.0	2.0	1.0	0.0	14.6	6.5
	16	0.0	0.0	0.0	4.0	14.9	13.9	10.9	5.9	6.9	10.9	10.9	11.9	7.9	1.0	1.0	0.0	14.7	6.6
	17	0.0	0.0	0.0	7.8	12.6	9.7	14.6	7.8	4.9	8.7	10.7	14.6	6.8	1.9	0.0	0.0	14.7	6.6
	18	0.0	0.0	1.0	7.7	9.6	16.3	8.7	11.5	3.8	13.5	9.6	10.6	5.8	1.9	0.0	0.0	14.2	6.4
	19	0.0	0.0	0.0	8.7	9.6	13.5	10.6	13.5	6.7	10.6	13.5	5.8	6.7	1.0	0.0	0.0	13.9	6.2
	20	0.0	0.0	2.9	10.6	7.7	12.5	15.4	14.4	5.8	12.5	6.7	8.7	2.9	0.0	0.0	0.0	12.9	5.8
	21	0.0	0.0	1.0	12.5	17.3	14.4	12.5	10.6	12.5	6.7	4.8	6.7	1.0	0.0	0.0	0.0	11.5	5.1
	22	0.0	0.0	5.7	13.3	19.0	15.2	9.5	9.5	6.7	5.7	7.6	5.7	1.9	0.0	0.0	0.0	10.9	4.9
	23	0.0	0.0	6.7	20.0	12.4	12.4	10.5	5.7	11.4	9.5	5.7	4.8	0.0	1.0	0.0	0.0	10.9	4.9
	24	0.0	0.0	9.6	27.9	14.4	9.6	7.7	4.8	7.7	6.7	9.6	1.9	0.0	0.0	0.0	0.0	9.6	4.3
ALL HOURS		0.0	0.7	11.6	16.9	11.8	11.0	9.2	7.0	6.1	7.5	7.1	7.6	2.5	0.7	0.4	0.0	11.2	5.0

SOURCE: GEORESEARCH, INC.

Table IV - 122

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

(AUTUMN)

09/01/80 - 06/30/82

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (METERS/SECOND)															
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.1	8.1-9.0	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	0.6	12.2	11.0	11.0	8.1	10.5	6.4	5.2	5.8	5.2	10.5	6.4	1.7	4.1	1.2	13.9	6.2
	2	0.0	0.0	9.3	18.0	10.5	5.8	8.1	9.3	3.5	4.7	7.0	9.3	7.0	4.1	2.3	1.2	13.8	6.2
	3	0.0	1.2	13.5	12.3	8.2	6.4	7.0	7.6	6.4	7.0	3.5	13.5	5.3	4.7	2.9	0.6	14.1	6.3
	4	0.0	0.0	13.5	11.8	8.8	4.1	5.3	10.6	4.1	4.7	7.6	11.8	8.8	4.7	2.9	1.2	14.9	6.7
	5	0.0	0.0	17.5	9.4	10.5	1.8	7.0	5.3	8.2	5.8	5.8	12.9	8.2	2.3	4.1	1.2	14.6	6.5
	6	0.0	0.0	14.6	12.3	8.8	4.7	7.0	5.8	4.7	6.4	5.3	13.5	8.8	5.3	2.9	0.0	14.6	6.5
	7	0.0	0.6	12.8	12.2	11.0	4.7	2.9	6.4	6.4	5.2	5.8	14.5	9.9	2.9	4.1	0.6	14.9	6.7
	8	0.0	0.6	9.9	9.4	10.5	9.9	4.7	5.3	2.9	8.8	5.3	11.7	12.3	3.5	4.1	1.2	15.7	7.0
H	9	0.0	0.6	9.9	9.3	8.7	5.2	7.0	5.8	5.8	6.4	4.7	16.3	8.7	5.8	2.9	2.9	16.5	7.4
	10	0.0	0.0	9.3	5.8	5.8	4.1	8.7	10.5	2.3	7.0	6.4	15.7	12.2	6.4	2.9	2.9	17.7	7.9
O	11	0.0	0.6	5.9	8.2	6.5	4.7	4.1	8.2	7.6	3.5	6.5	18.8	12.4	5.9	4.1	2.9	18.2	8.1
	12	0.0	0.0	5.9	8.8	6.5	4.7	4.7	2.9	7.6	7.1	10.6	15.9	12.9	7.1	4.1	1.2	18.2	8.1
U	13	0.0	0.0	5.4	6.6	7.2	4.8	7.8	3.6	6.0	9.6	10.8	16.2	14.4	2.4	4.2	1.2	17.8	8.0
	14	0.0	0.0	4.8	4.8	6.1	7.3	9.1	6.7	10.3	5.5	9.1	17.6	12.7	1.2	3.0	1.8	17.3	7.7
R	15	0.0	0.0	3.0	7.8	7.2	4.8	9.0	6.0	8.4	12.7	10.2	17.5	6.6	3.0	2.4	1.2	16.6	7.4
	16	0.0	0.0	2.4	6.5	8.2	6.5	5.3	10.6	13.5	8.2	11.2	12.9	7.6	3.5	1.8	1.8	16.8	7.5
	17	0.0	0.0	2.9	6.4	5.2	7.6	11.6	14.5	9.3	8.1	6.4	14.5	5.2	5.8	1.2	1.2	16.1	7.2
	18	0.0	0.0	2.9	8.7	5.2	9.2	13.9	13.3	6.9	11.0	8.1	8.7	5.8	3.5	0.0	2.9	15.3	6.9
	19	0.0	0.0	5.2	9.2	8.1	9.2	17.3	9.8	6.4	8.7	6.9	8.7	5.2	2.3	0.6	2.3	14.3	6.4
	20	0.0	0.0	5.2	12.7	7.5	11.0	11.0	11.0	9.8	5.2	5.8	9.8	6.9	1.7	0.6	1.7	14.0	6.3
	21	0.0	0.0	11.0	9.8	9.2	10.4	11.6	8.7	7.5	5.8	4.6	9.2	7.5	2.3	0.6	1.7	13.8	6.2
	22	0.0	0.0	10.9	16.1	9.2	6.9	8.0	9.8	9.2	3.4	5.7	9.2	4.6	5.2	0.0	1.7	13.4	6.0
	23	0.0	0.0	12.7	13.9	10.4	9.8	4.6	7.5	8.1	7.5	5.8	8.1	4.6	3.5	1.7	1.7	13.4	6.0
	24	0.0	0.6	12.7	15.6	7.5	4.6	12.1	6.9	5.8	5.2	5.8	9.8	5.8	4.6	1.7	1.2	13.6	6.1
ALL HOURS		0.0	0.2	8.9	10.3	8.3	6.5	8.3	8.0	6.9	6.8	6.8	12.7	8.3	3.9	2.5	1.6	15.4	6.9

SOURCE: GEORESEARCH, INC.

Table IV - 123

Annual Wind Rose Distribution

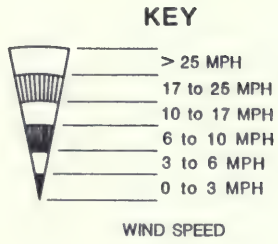
PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

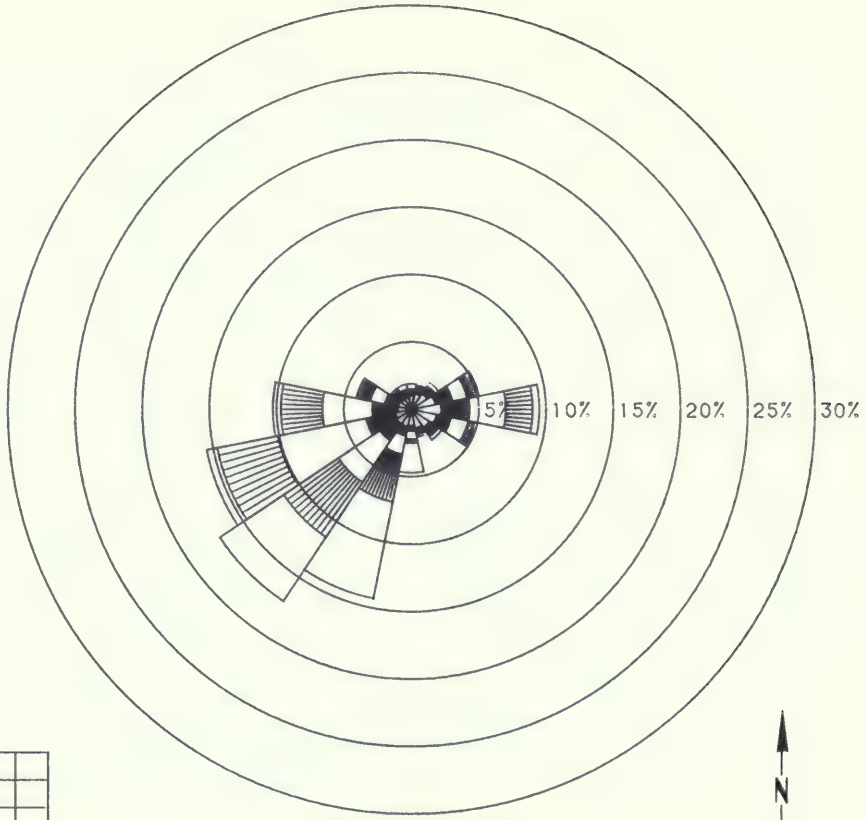
09/01/80 - 06/30/82

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1- 0.4
1.1- 2.0	0.1	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.8	0.5- 0.9
2.1- 3.0	0.2	0.2	0.1	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	3.1	1.0- 1.3
3.1- 4.0	0.2	0.3	0.4	0.3	0.6	0.7	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	5.5	1.4- 1.8
S 4.1- 5.0	0.2	0.4	0.4	0.5	0.6	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	5.6	1.9- 2.2
P 5.1- 6.0	0.3	0.3	0.4	0.6	0.6	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.3	5.2	2.3- 2.7
E 6.1- 7.0	0.2	0.2	0.2	0.4	0.5	0.4	0.2	0.2	0.1	0.3	0.3	0.4	0.4	0.2	0.3	0.2	4.4	2.8- 3.1
E 7.1- 8.0	0.1	0.2	0.1	0.4	0.6	0.3	0.2	0.2	0.1	0.2	0.4	0.5	0.5	0.3	0.3	0.1	4.3	3.2- 3.6
D 8.1- 9.0	0.1	0.1	0.2	0.3	0.6	0.2	0.2	0.1	0.1	0.1	0.4	0.5	0.5	0.3	0.1	0.2	3.8	3.7- 4.0
9.1-10.0	0.1	0.1	0.1	0.2	0.4	0.2	0.2	0.0	0.1	0.1	0.4	0.8	0.5	0.2	0.1	0.1	3.6	4.1- 4.5
M 10.1-11.0	0.1	0.0	0.0	0.2	0.3	0.3	0.1	0.0	0.1	0.2	0.5	0.8	0.6	0.2	0.1	0.1	3.5	4.6- 4.9
I 11.1-12.0	0.1	0.0	0.1	0.2	0.5	0.2	0.1	0.0	0.1	0.2	0.5	0.9	0.5	0.2	0.0	0.0	3.6	5.0- 5.4
L 12.1-13.0	0.1	0.0	0.0	0.2	0.4	0.2	0.1	0.0	0.0	0.2	0.5	0.9	0.6	0.1	0.1	0.1	3.6	5.5- 5.8
E 13.1-14.0	0.1	0.0	0.0	0.1	0.4	0.2	0.0	0.0	0.1	0.1	0.5	1.0	0.4	0.1	0.0	0.1	3.3	5.9- 6.3
S 14.1-15.0	0.0	0.0	0.0	0.1	0.4	0.2	0.0	0.0	0.1	0.3	0.6	1.0	0.6	0.2	0.0	0.0	3.6	6.4- 6.7
/ 15.1-16.0	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	0.1	0.2	0.6	1.0	0.4	0.1	0.0	0.1	3.0	6.8- 7.2
H 16.1-17.0	0.0	0.0	0.0	0.2	0.4	0.1	0.0	0.0	0.1	0.2	0.5	1.1	0.6	0.2	0.0	0.0	3.5	7.3- 7.6
O 17.1-18.0	0.0	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.3	0.5	0.9	0.7	0.2	0.0	0.0	3.2	7.7- 8.0
U 18.1-19.0	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.4	0.6	0.8	0.6	0.1	0.0	0.0	3.2	8.1- 8.5
R 19.1-20.0	0.0	0.0	0.0	0.1	0.4	0.1	0.0	0.0	0.1	0.5	0.6	0.6	0.5	0.2	0.0	0.0	3.2	8.6- 8.9
20.1-25.0	0.0	0.0	0.0	0.4	0.9	0.2	0.0	0.0	0.2	2.4	3.2	2.3	1.3	0.5	0.0	0.0	11.4	9.0-11.2
25.1-30.0	0.0	0.0	0.0	0.1	0.4	0.1	0.0	0.0	0.2	2.5	2.4	0.7	0.4	0.1	0.0	0.0	6.9	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.9	1.6	0.1	0.1	0.0	0.0	0.0	4.3	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.5	1.0	0.0	0.0	0.0	0.0	0.0	3.1	15.7-17.9
>40.0	0.0	0.1	0.3	0.0	0.1	0.0	0.0	0.2	0.9	1.4	0.7	0.0	0.1	0.0	0.0	0.0	3.6	>17.9
CALM																	0.0	CALM
TOTAL	1.9	1.9	2.4	5.1	9.5	4.8	2.5	2.1	4.7	14.3	17.1	15.5	10.3	4.1	1.9	1.9	0.0	TOTAL
AV SPEED (MPH)	6.9	5.6	6.4	10.1	12.0	9.1	5.9	6.8	23.5	25.3	20.8	14.9	14.2	12.0	6.7	7.7	15.6	AV SPEED (MPH)
AV SPEED (M/SEC)	3.1	2.5	2.9	4.5	5.4	4.1	2.6	3.1	10.5	11.3	9.3	6.7	6.4	5.4	3.0	3.4	7.0	AV SPEED (M/SEC)

SOURCE: GEORESEARCH, INC.

Figure IV - 13
Annual Wind Rose
LIVINGSTON CANDIDATE WIND TURBINE SITE — PARK COUNTY
(1980 - 1982)





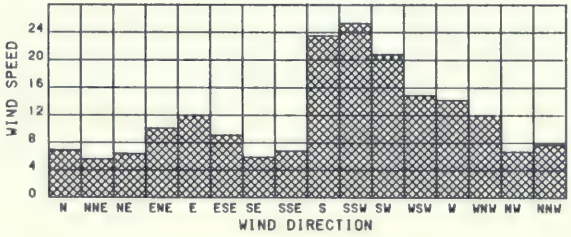


Table IV - 124

Coefficients of Weibull Distribution

PARK COUNTY - LIVINGSTON CANDIDATE WIND TURBINE SITE

09/01/80 - 06/30/82

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	8.7041	1.4656
FEBRUARY	13.0890	1.0187
MARCH	6.2942	1.4434
APRIL	7.7433	1.4614
MAY	5.1236	1.7195
JUNE	5.6831	1.7094
JULY	5.8437	1.6060
AUGUST	4.3808	1.6394
SEPTEMBER	5.3428	1.6717
OCTOBER	7.5914	1.5903
NOVEMBER	10.3296	1.7203
DECEMBER	12.2643	1.5990
YEAR	7.5403	1.4615

SOURCE: GEORESEARCH, INC.

LIVINGSTON FAA AIRPORT

PARK COUNTY

The old Livingston airport, now abandoned, was located approximately 1 mile east of Livingston at 45 40 12 N and 110 31 48 W (Site No. 96 on Map II-1). The airport sat in the Yellowstone River Valley at an elevation of 4,590 feet, just north of the Absaroka Mountains, which rise to more than 11,000 feet. To the southwest is the Gallatin Range, and to the northwest is the Bridger Range. Both ranges have summits over 9,000 feet. Northeast of the area are the Crazy Mountains, which rise to over 11,000 feet. Two major river valleys intersect in this area: the Paradise Valley to the southwest, through which the upper Yellowstone River flows, and the Shields River Valley to the north.

Most of the land in the valley is privately owned, although there are a few scattered sections of publicly owned land. Land in the mountains is controlled predominantly by the U.S. Forest Service. Much of the privately owned land has been leased for wind energy use.

Electrical service in the area is provided by the Montana Power Company and the Park Electric Cooperative. A number of transmission lines run through the valley.

Meteorological data had been collected at this site for several years by the Federal Aviation Administration. These data, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories.

The Battelle data set for Livingston consists of summaries, for two time periods, of data gathered at different anemometer heights: January 1, 1948, through July 4, 1953; and July 5, 1953, through December 31, 1954. Only hourly data from the earlier period were selected for inclusion in this *Atlas*. These data were gathered by an anemometer mounted on a beacon tower at a height of 17.4 meters. Because of complex terrain in the area, the site is representative only of a limited area of the upper Yellowstone River Valley near Livingston.

Average annual wind speed at the site was 15.7 miles per hour. Average monthly wind speeds varied from 10.7 miles per hour in July to 21.9 miles per hour in January.

Average annual wind power was 510.0 watts/m^2. Average monthly wind power ranged from 137.0 watts/m^2 in July to 1,175.0 watts/m^2 in January.

Average seasonal wind speeds were 11.4 miles per hour in summer, 14.5 miles per hour in spring, 15.4 miles per hour in autumn, and 21.1 miles per hour in winter. The highest average wind speeds occurred around noon in winter, early to mid-afternoon in spring and autumn, and late afternoon in summer. The lowest average wind speeds occurred shortly after midnight in autumn, in the early morning in spring and summer, and in early evening in winter. The diurnal range of average wind speeds was greatest in summer and least in winter.

The most common wind directions were south-southwest through west-southwest. Winds from the southeast and west-northwest were least common. By direction, average wind speeds ranged from 6.0 miles per hour for southeast winds to 24.6 miles per hour for winds from the south-southwest. The strongest winds were from the prevailing wind directions.

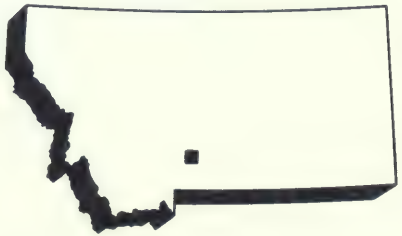


Table IV - 125

Monthly Wind Speed Distribution

PARK COUNTY - LIVINGSTON FAA AIRPORT

01/01/48 - 07/04/53

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	1.3	1.1	2.2	1.5	1.2	1.4	2.0	2.0	1.9	2.8	1.6	1.9	1.7	CALM (<0.5)
1.1- 3.1	1.8	1.1	2.3	1.5	2.3	1.6	4.2	3.1	2.5	2.5	0.7	1.0	2.0	0.5- 1.4
3.4- 5.4	7.2	7.2	11.1	11.8	14.7	14.8	19.8	17.7	17.6	14.8	6.5	7.4	12.5	1.5- 2.4 S
S 5.6- 7.6	4.4	4.6	6.0	7.2	7.8	9.4	11.6	11.9	9.3	7.6	4.2	4.2	7.3	2.5- 3.4 P
P 7.8- 9.8	4.6	5.7	6.5	9.4	10.3	12.4	12.5	11.6	10.8	7.2	5.0	4.9	8.4	3.5- 4.4 E
E 10.1-12.1	8.8	10.2	13.2	15.9	16.1	19.4	16.7	17.4	18.1	13.9	11.9	9.0	14.2	4.5- 5.4 E
E 12.3-14.3	5.3	4.8	5.9	7.2	6.8	6.8	7.3	7.0	7.1	6.6	6.5	5.4	6.4	5.5- 6.4 D
D 14.5-16.6	6.4	6.1	7.3	8.4	7.9	7.5	5.3	7.1	7.4	6.0	8.0	7.0	7.1	6.5- 7.4
16.8-18.8	9.7	11.5	12.8	13.0	10.9	10.2	8.4	8.2	9.7	10.1	13.0	11.5	10.8	7.5- 8.4 M
M 19.0-21.0	7.1	8.6	8.2	8.1	8.1	6.9	5.3	5.2	5.8	7.0	9.1	8.4	7.4	8.5- 9.4 E
I 21.3-23.3	4.1	5.2	4.6	4.1	3.6	3.0	2.0	3.0	2.2	2.8	4.7	4.6	3.7	9.5-10.4 T
L 23.5-25.5	5.4	5.2	4.5	3.8	3.5	2.4	2.3	2.0	2.7	2.9	5.3	4.8	3.8	10.5-11.4 E
E 25.7-27.7	5.4	5.4	4.4	3.3	3.1	1.6	0.9	1.7	2.2	4.1	5.5	5.1	3.6	11.5-12.4 R
S 28.0-30.0	4.1	3.4	2.6	1.4	1.6	0.9	0.7	0.7	1.1	2.5	3.2	3.5	2.2	12.5-13.4 S
/ 30.2-32.2	2.8	2.4	1.7	1.0	0.7	0.5	0.3	0.5	0.4	1.7	1.9	2.8	1.4	13.5-14.4 /
H 32.4-34.4	4.1	3.1	2.0	0.6	0.8	0.2	0.5	0.4	0.5	1.8	2.7	4.7	1.8	14.5-15.4 S
O 34.7-36.7	1.7	1.1	0.6	0.3	0.3	0.3	0.2	0.1	0.2	0.9	1.2	2.2	0.8	15.5-16.4 E
U 36.9-38.9	2.3	1.8	0.7	0.4	0.0	0.2	0.0	0.1	0.1	0.9	1.2	2.1	0.8	16.5-17.4 C
R 39.1-41.2	2.8	2.2	0.8	0.4	0.1	0.2	0.1	0.1	0.2	1.0	1.8	2.8	1.0	17.5-18.4 O
41.4-43.4	2.4	1.7	0.7	0.3	0.1	0.2	0.0	0.1	0.0	0.7	1.7	1.5	0.8	18.5-19.4 N
43.6-45.6	2.3	1.7	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.9	1.5	1.6	0.7	19.5-20.4 D
45.9-56.8	5.2	5.0	0.9	0.1	0.0	0.1	0.0	0.1	0.0	1.1	2.6	2.9	1.5	20.5-25.4
57.0-68.0	0.7	1.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.2	25.5-30.4
68.2-79.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	21.9	20.8	16.1	14.1	13.2	12.3	10.7	11.2	11.9	15.0	19.2	20.6	15.7	
AVERAGE SPEED (M/SEC)	9.8	9.3	7.2	6.3	5.9	5.5	4.8	5.0	5.3	6.7	8.6	9.2	7.0	
AVERAGE WIND POWER (WATTS/M**2)	1175.0	1055.0	513.0	293.0	230.0	191.0	137.0	153.0	178.0	446.0	769.0	949.0	510.0	

ANEMOMETER HEIGHT = 57.0 FEET = 17.4 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 126

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON FAA AIRPORT (WINTER)

01/01/48 - 07/04/53

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
			WIND SPEED (M/SEC)															AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	2.4	0.9	9.2	3.7	5.5	8.7	5.0	4.6	11.7	7.2	4.1	5.5	4.1	5.1	2.7	19.7	21.0	9.4
	2	1.4	1.5	9.2	4.7	5.3	8.1	4.5	6.1	11.1	7.3	4.2	4.8	7.3	3.3	3.2	18.0	20.6	9.2
	3	1.2	1.9	9.1	2.9	4.6	10.7	5.1	5.7	13.2	7.1	2.8	6.8	6.3	4.9	2.1	15.7	20.3	9.1
	4	2.8	1.6	9.1	4.1	3.8	9.4	5.2	4.9	11.5	9.5	4.8	5.4	5.6	1.9	3.7	16.7	20.5	9.2
	5	1.6	2.2	7.3	5.8	4.1	8.6	5.3	8.0	11.6	8.1	5.6	4.0	5.1	3.2	2.2	17.3	20.4	9.1
	6	2.2	2.4	7.7	3.1	5.0	9.2	4.8	6.7	12.0	8.6	4.4	3.6	5.1	3.2	4.0	18.0	20.7	9.3
	7	2.6	1.0	7.0	5.0	4.7	8.6	6.6	6.5	10.2	7.9	4.8	3.9	6.5	3.3	3.8	17.6	20.7	9.2
	8	1.8	0.8	8.3	4.5	5.6	7.9	5.7	6.3	10.2	7.3	5.7	4.5	5.5	4.1	2.0	19.6	20.8	9.3
H	9	1.8	0.8	6.1	4.9	5.2	11.1	3.8	5.2	11.2	10.7	3.7	6.5	4.7	3.8	1.7	18.9	21.2	9.5
	10	1.4	1.6	5.6	3.6	4.6	10.2	4.6	7.2	8.2	9.8	5.9	4.9	5.4	3.0	2.3	21.6	22.0	9.8
O	11	1.4	0.7	5.6	4.0	4.9	9.2	2.5	7.9	9.4	9.8	5.1	5.3	6.1	4.0	3.0	21.2	22.4	10.0
	12	1.0	1.3	4.7	4.0	5.0	6.7	4.7	5.6	9.0	10.2	5.6	5.2	6.1	5.5	2.5	23.0	23.3	10.4
U	13	0.8	1.1	4.7	3.6	4.3	6.9	4.7	6.4	11.8	9.3	4.4	6.3	6.6	4.5	2.8	21.8	22.8	10.2
	14	0.4	0.8	5.0	4.5	3.1	9.2	4.7	7.4	11.1	9.5	4.7	6.0	4.6	4.5	3.9	20.5	22.6	10.1
R	15	0.8	1.1	4.7	2.3	5.3	9.7	3.5	8.4	13.2	9.4	4.6	5.8	4.8	4.1	2.0	20.2	21.9	9.8
	16	0.2	0.4	4.8	6.5	3.5	9.5	6.9	8.0	10.7	8.7	5.3	5.2	6.7	3.3	2.8	17.7	21.3	9.5
	17	1.3	0.8	8.0	4.0	4.5	9.1	6.0	7.2	14.5	6.4	4.1	5.8	4.0	3.5	1.9	19.1	20.8	9.3
	18	1.1	1.7	7.0	3.8	5.4	10.1	6.5	7.0	13.5	8.5	3.7	5.8	4.7	2.0	2.1	17.2	20.2	9.0
	19	1.4	1.4	7.7	4.5	6.6	10.4	6.1	6.8	9.7	7.2	4.1	4.2	5.6	3.1	2.3	19.0	20.4	9.1
	20	1.5	0.9	7.1	5.7	6.2	11.5	6.1	6.8	10.0	3.9	5.1	4.8	4.6	4.5	2.2	19.0	20.6	9.2
	21	1.0	1.8	8.1	6.5	7.4	7.6	5.1	7.1	10.2	5.4	4.3	6.1	3.8	4.0	1.8	19.8	20.5	9.1
	22	1.2	1.4	10.8	4.3	6.4	9.1	6.1	5.5	8.8	5.0	5.0	5.0	5.5	2.8	3.4	19.6	20.7	9.2
	23	1.2	1.9	7.7	4.1	5.9	12.6	5.6	6.0	9.4	6.7	4.0	4.0	4.3	2.6	2.8	21.3	20.7	9.2
	24	2.0	2.1	9.6	5.2	4.0	9.4	4.9	4.9	8.4	8.9	4.6	4.0	4.0	4.5	2.5	21.1	20.8	9.3
ALL HOURS		1.4	1.3	7.3	4.4	5.0	9.3	5.2	6.5	10.9	8.0	4.6	5.1	5.3	3.7	2.7	19.3	21.1	9.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 127

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON FAA AIRPORT (SPRING)

01/01/48 - 07/04/53

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	2.4	1.8	14.9	7.8	11.1	17.9	5.1	5.8	10.3	7.6	4.2	3.4	2.7	1.1	0.7	3.3	13.3	5.9
	2	2.7	2.9	17.4	7.1	12.5	13.1	6.2	6.0	8.9	8.2	4.0	2.7	2.5	2.5	0.5	2.9	13.0	5.8
	3	2.2	2.0	16.5	10.1	11.1	15.4	5.2	6.3	10.9	5.4	3.6	2.5	3.8	1.7	0.9	2.4	12.9	5.8
	4	3.7	4.0	16.7	6.7	9.2	14.8	4.7	7.8	11.8	5.8	3.8	3.3	3.1	1.5	0.2	3.1	12.9	5.8
	5	2.2	3.8	17.8	8.5	7.8	13.0	7.6	7.5	9.5	7.1	5.1	2.7	3.8	0.7	0.7	2.3	13.0	5.8
	6	2.5	3.1	18.1	10.3	6.6	12.7	6.5	5.3	11.2	8.0	3.8	4.7	3.1	1.3	0.7	2.2	13.0	5.8
	7	2.7	3.6	15.9	5.8	11.6	12.3	6.3	7.8	10.3	7.4	2.5	5.2	4.6	0.9	0.7	2.2	13.2	5.9
	8	2.2	3.1	12.3	7.1	4.7	16.6	8.0	8.3	12.0	9.2	3.3	2.6	4.0	1.6	1.8	3.3	14.4	6.4
H	9	1.6	2.7	12.5	5.1	5.8	12.3	8.3	7.5	14.0	9.8	3.6	4.0	4.1	2.2	1.1	5.5	15.4	6.9
	10	2.2	2.4	10.9	4.9	6.7	12.5	6.2	9.1	11.8	9.8	5.3	5.8	4.2	2.9	1.5	4.2	15.7	7.0
O	11	0.7	2.0	9.1	6.7	7.6	12.5	6.7	9.1	13.6	9.8	5.5	4.2	4.4	2.0	1.6	4.7	15.8	7.1
	12	1.1	2.2	8.9	3.4	6.9	12.5	6.5	10.3	15.6	11.4	4.0	5.3	4.3	2.8	0.6	4.3	16.1	7.2
U	13	0.6	0.9	6.0	5.4	9.4	13.6	8.1	9.8	15.4	8.0	6.2	4.7	3.8	1.6	1.8	4.7	16.3	7.3
	14	0.3	1.6	6.9	5.3	7.2	13.0	8.7	8.0	13.2	12.7	4.0	4.9	5.8	2.9	1.1	4.4	16.6	7.4
R	15	0.2	0.7	6.9	5.6	8.7	13.8	6.2	11.4	12.1	9.8	5.8	5.6	4.0	2.9	1.6	4.8	16.7	7.5
	16	0.7	0.5	6.6	6.2	6.2	15.4	7.6	9.4	15.8	10.3	4.3	4.3	4.0	2.0	2.0	4.7	16.6	7.4
	17	0.2	0.2	9.1	5.6	7.3	15.2	7.6	8.5	16.9	8.7	5.6	4.2	3.6	2.2	1.3	4.0	16.1	7.2
	18	0.7	1.6	8.9	5.3	9.4	15.9	6.0	9.6	17.2	6.7	5.1	3.6	3.3	1.3	1.4	3.9	15.4	6.9
	19	1.4	0.9	10.0	6.3	8.0	20.5	8.9	8.3	12.2	7.4	3.7	4.2	2.2	1.8	1.8	2.4	14.4	6.4
	20	1.5	1.3	14.5	7.0	11.4	19.4	6.0	7.3	11.6	6.0	2.5	2.4	3.6	1.8	1.5	2.3	13.4	6.0
	21	2.0	1.3	14.7	10.1	10.3	18.1	4.9	7.4	10.7	5.4	2.6	3.6	3.1	1.1	2.0	2.8	13.3	5.9
	22	2.3	3.1	15.1	8.3	10.9	15.8	6.0	5.4	8.2	8.2	3.6	4.2	2.5	2.7	0.9	2.9	13.4	6.0
	23	1.8	1.4	13.9	10.1	12.0	16.9	4.9	6.9	9.1	7.3	3.8	3.1	2.9	1.6	0.7	3.6	13.3	6.0
	24	1.6	1.6	17.6	8.9	8.0	18.3	6.9	6.2	11.2	5.8	2.0	3.2	2.9	1.7	0.9	3.2	13.1	5.9
ALL HOURS		1.6	2.0	12.5	7.0	8.7	15.1	6.6	7.9	12.2	8.1	4.1	3.9	3.6	1.9	1.1	3.5	14.5	6.5

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 128

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON FAA AIRPORT (SUMMER)

01/01/48 - 07/04/53

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	1.2	4.5	22.8	11.0	17.2	17.6	6.9	6.0	6.3	2.2	1.6	1.9	0.4	0.2	0.0	0.2	9.5	4.3
	2	2.6	2.5	27.7	12.9	12.2	15.9	5.2	5.2	8.1	3.5	1.2	1.1	0.8	0.2	0.0	0.8	9.5	4.2
	3	3.1	7.3	25.5	13.3	12.3	18.1	2.3	3.8	7.5	3.0	1.4	1.0	0.6	0.2	0.2	0.2	8.9	4.0
	4	4.1	5.5	30.1	11.8	12.6	13.7	5.0	4.7	5.8	3.3	1.1	1.0	0.4	0.2	0.0	0.6	8.6	3.8
	5	5.6	8.1	26.3	11.7	11.7	15.0	3.8	4.1	5.3	5.6	1.0	0.2	0.2	0.2	0.8	0.6	8.6	3.8
	6	4.3	6.9	29.9	9.0	13.6	14.0	5.3	3.8	6.2	3.0	1.4	1.4	0.2	0.6	0.4	0.2	8.6	3.9
	7	6.4	6.9	21.2	12.0	13.9	13.2	4.5	4.0	7.7	5.0	2.4	0.9	0.6	0.2	0.4	0.6	9.3	4.2
	8	2.8	5.5	24.2	10.5	8.3	15.3	5.5	6.7	9.5	4.5	2.1	2.4	0.4	1.2	0.6	0.4	10.3	4.6
H	9	1.6	2.5	16.4	12.3	10.5	22.0	6.9	4.9	10.0	6.1	2.6	1.6	1.4	0.6	0.4	0.2	11.2	5.0
	10	1.7	1.8	15.6	12.5	11.7	19.0	8.4	8.0	7.9	4.9	3.9	2.0	1.8	0.4	0.0	0.4	11.3	5.1
O	11	0.6	2.4	17.5	11.7	10.1	17.8	6.6	8.1	9.1	7.4	2.8	2.4	1.0	1.4	0.4	0.8	11.8	5.3
	12	0.6	1.7	16.2	10.8	10.6	17.6	8.6	7.0	8.7	7.9	3.3	2.4	1.8	1.6	0.2	1.0	12.2	5.5
U	13	0.4	1.3	12.0	7.8	11.0	18.7	7.9	8.9	10.1	9.1	3.4	3.6	1.8	1.6	0.6	1.8	13.4	6.0
	14	0.8	1.2	8.4	10.5	10.5	17.2	6.9	8.8	10.7	10.8	5.0	3.6	2.0	1.2	0.6	1.8	13.9	6.2
R	15	1.0	0.8	6.7	9.8	10.3	16.7	8.5	9.0	10.6	9.2	4.5	5.4	2.4	1.6	0.6	2.8	14.7	6.6
	16	0.0	0.4	8.5	7.9	8.5	15.4	11.7	9.8	10.0	11.3	5.4	2.8	4.0	1.7	0.4	2.2	14.8	6.6
	17	0.2	0.4	6.6	7.0	11.7	19.5	9.6	7.1	15.4	8.6	3.8	4.4	2.0	0.9	1.4	1.4	14.4	6.4
	18	0.4	0.4	9.1	6.9	10.2	18.9	8.7	8.4	15.2	9.1	2.4	3.0	2.7	1.8	1.3	1.6	14.2	6.4
	19	0.8	0.4	11.2	9.1	11.7	20.0	7.5	9.3	11.8	6.7	3.9	2.8	1.8	1.2	0.6	1.0	13.1	5.9
	20	0.4	1.6	13.3	10.2	13.5	20.3	8.1	8.2	9.0	5.8	3.2	2.8	1.8	0.4	0.2	1.0	12.1	5.4
	21	0.8	1.7	15.3	9.5	17.1	21.0	8.7	6.8	9.1	3.2	2.6	1.8	0.8	0.4	0.8	0.4	11.3	5.1
	22	1.5	1.7	15.3	12.3	16.0	25.6	7.6	4.6	7.2	2.7	1.4	1.6	1.4	0.0	0.0	1.0	10.7	4.8
	23	1.0	1.5	18.8	15.6	16.4	16.9	8.3	6.9	6.5	3.3	1.8	0.8	1.4	0.4	0.4	0.2	10.3	4.6
	24	1.4	4.3	21.1	17.4	10.8	18.5	6.1	5.1	6.3	3.0	1.9	2.1	1.3	0.2	0.2	0.4	9.8	4.4
ALL HOURS		1.8	3.0	17.5	11.0	12.2	17.8	7.0	6.6	8.9	5.8	2.7	2.2	1.4	0.8	0.4	1.0	11.4	5.1

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 129

Percentage Frequency Summary for Wind Speed

PARK COUNTY - LIVINGSTON FAA AIRPORT (AUTUMN)

01/01/48 - 07/04/53

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
	1	2.8	2.9	21.3	7.7	9.7	12.5	5.7	3.1	10.1	7.0	2.6	4.0	3.1	1.3	0.7	5.4	13.3	5.9
	2	4.6	3.7	18.7	6.4	8.6	12.3	4.9	7.9	8.1	6.8	2.4	3.5	3.8	2.2	1.8	4.4	13.4	6.0
	3	4.0	4.6	14.9	8.3	9.0	11.0	5.5	5.5	12.3	5.3	2.4	3.7	5.1	2.0	1.1	5.3	13.9	6.2
	4	3.3	3.1	18.7	5.7	7.5	10.1	6.4	5.7	12.3	6.2	4.2	3.7	3.5	2.6	1.6	5.5	14.5	6.5
	5	4.4	3.9	13.4	6.0	8.6	14.3	6.8	6.6	9.4	5.5	3.7	3.3	3.5	3.1	1.8	5.8	14.5	6.5
	6	4.2	2.0	15.4	6.2	7.7	14.0	6.4	6.4	12.3	5.7	2.8	4.2	3.5	1.1	1.5	6.6	14.5	6.5
	7	3.6	3.8	15.4	7.9	5.3	15.4	5.7	6.6	9.2	6.4	3.9	4.0	3.1	2.0	1.3	6.6	14.5	6.5
	8	4.4	2.2	14.7	5.5	7.0	14.1	3.3	8.1	10.1	7.7	3.7	3.7	3.9	2.2	1.5	7.7	15.2	6.8
H	9	1.3	2.2	10.8	5.9	7.0	14.1	7.5	7.5	9.0	11.0	4.4	4.2	4.2	2.4	0.9	7.7	16.3	7.3
	10	1.5	1.3	8.8	5.5	5.9	16.0	8.8	6.6	12.5	7.0	4.2	5.1	5.3	2.4	0.7	8.2	16.9	7.6
O	11	0.4	1.3	10.3	5.3	5.7	14.0	5.9	7.2	13.9	8.6	2.8	4.0	4.4	4.6	2.0	9.4	17.7	7.9
	12	1.1	0.9	7.9	6.0	5.3	16.5	8.3	7.0	9.9	9.2	3.8	4.6	5.3	2.6	1.3	10.4	17.6	7.9
U	13	0.2	0.6	8.1	5.9	6.4	16.1	6.6	8.1	11.2	9.2	5.3	5.5	3.5	3.7	0.7	8.8	17.5	7.8
	14	0.4	0.9	7.7	5.5	4.4	14.3	7.9	7.5	11.7	12.8	4.9	3.5	5.5	2.6	2.4	8.1	17.8	8.0
R	15	0.2	0.4	5.5	5.5	5.5	14.7	8.6	9.9	14.1	11.4	3.9	3.3	5.0	1.5	1.7	8.6	17.7	7.9
	16	0.4	0.4	7.3	4.4	7.7	12.8	8.1	11.0	14.3	10.1	4.2	3.9	3.7	3.1	0.6	7.9	17.2	7.7
	17	0.2	0.9	9.0	3.5	7.7	16.2	10.8	9.9	14.7	7.2	2.8	5.3	2.4	1.5	0.7	7.0	16.2	7.2
	18	0.2	0.4	10.3	7.0	10.3	21.8	7.2	7.3	11.2	5.9	1.8	2.4	4.2	1.3	1.3	7.2	15.2	6.8
	19	0.5	1.3	12.3	9.2	9.6	20.0	7.7	6.3	10.1	5.3	2.0	3.3	2.0	1.5	1.5	7.3	14.7	6.6
	20	0.6	1.1	11.9	11.0	13.4	15.2	6.6	7.5	8.6	5.9	3.1	1.7	3.3	1.8	2.0	6.3	14.4	6.4
	21	2.4	1.3	14.3	10.6	9.9	15.0	4.8	6.6	10.1	4.4	2.6	3.5	4.6	1.8	1.5	6.6	14.5	6.5
	22	2.0	1.3	17.8	11.9	7.7	12.7	5.5	6.4	10.6	5.5	1.3	3.1	3.3	2.6	0.7	7.7	14.2	6.4
	23	2.9	1.3	20.4	11.0	5.9	13.6	5.5	6.0	7.2	5.7	2.9	2.4	4.6	2.4	1.5	6.5	13.9	6.2
	24	4.2	4.2	17.1	7.0	8.4	14.3	6.2	6.4	9.2	5.9	2.2	1.8	3.9	1.8	1.5	5.9	13.6	6.1
ALL HOURS		2.1	1.9	13.0	7.0	7.7	14.6	6.7	7.1	10.9	7.3	3.2	3.6	3.9	2.3	1.3	7.1	15.4	6.9

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 130

Annual Wind Rose Distribution

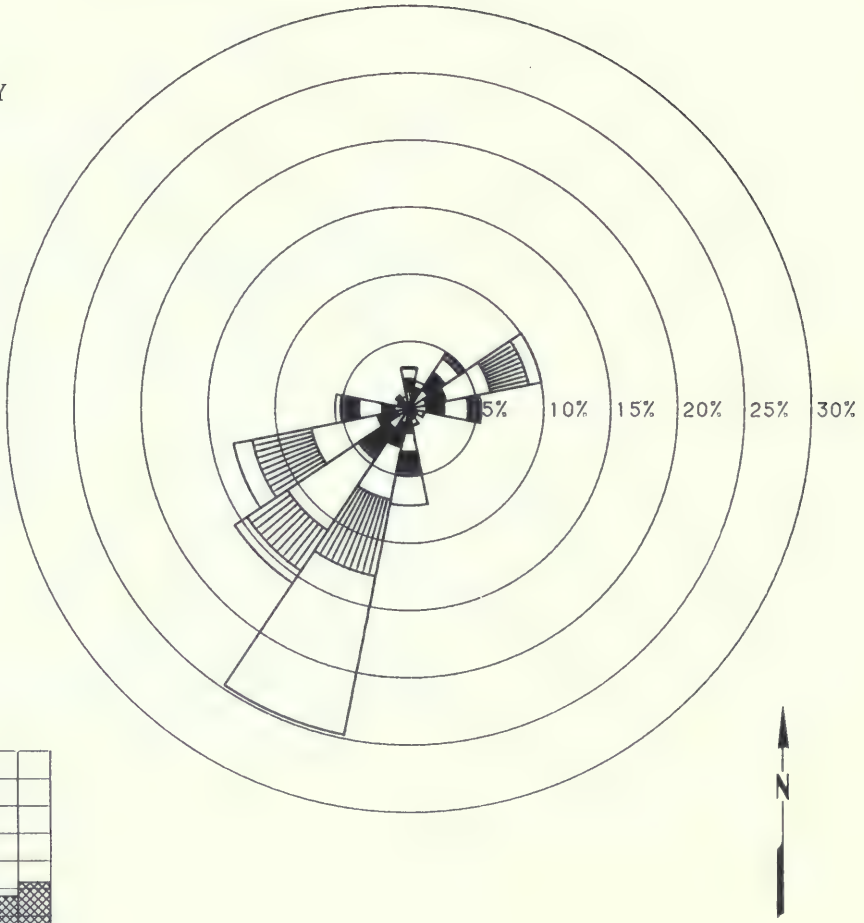
PARK COUNTY - LIVINGSTON FAA AIRPORT

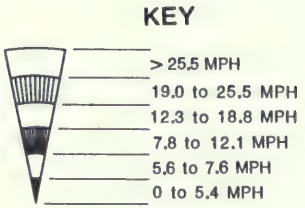
01/01/48 - 07/04/53

DIRECTION> / SPEED (MPH)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION / SPEED (M/SEC)
1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4
3.4- 5.4	0.2	0.1	0.3	0.2	0.2	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.0	0.1	0.0	2.0	1.5- 2.4
5.6- 7.6	1.1	0.7	1.4	1.1	1.1	0.3	0.3	0.3	0.7	1.0	1.6	0.8	0.9	0.2	0.5	0.3	12.3	2.5- 3.4
7.8- 9.8	0.5	0.4	0.8	0.7	0.6	0.2	0.1	0.2	0.5	0.8	1.1	0.6	0.5	0.1	0.2	0.1	7.4	3.5- 4.4
10.1-12.1	0.4	0.4	0.7	0.8	0.7	0.2	0.1	0.2	0.5	1.0	1.6	0.9	0.4	0.1	0.2	0.1	8.3	4.5- 5.4
12.3-14.3	0.5	0.3	0.8	1.6	1.0	0.2	0.1	0.2	0.7	1.8	3.4	2.3	0.8	0.1	0.2	0.2	14.2	5.5- 6.4
14.5-16.6	0.2	0.1	0.3	0.8	0.4	0.1	0.0	0.1	0.3	1.0	1.5	1.2	0.4	0.1	0.0	0.1	6.6	6.5- 7.4
16.8-18.8	0.1	0.1	0.2	1.0	0.4	0.1	0.0	0.1	0.4	1.2	1.5	1.5	0.5	0.1	0.0	0.1	7.3	7.5- 8.4
19.0-21.0	0.1	0.0	0.3	1.4	0.5	0.1	0.0	0.1	0.7	2.3	2.1	2.3	0.7	0.1	0.0	0.0	10.7	8.5- 9.4
21.3-23.3	0.0	0.0	0.1	1.0	0.2	0.0	0.0	0.0	0.7	2.2	1.1	1.5	0.5	0.1	0.0	0.0	7.4	9.5-10.4
23.5-25.5	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.4	1.3	0.4	0.7	0.2	0.0	0.0	0.0	3.6	10.5-11.4
25.7-27.7	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.4	1.5	0.4	0.6	0.2	0.0	0.0	0.0	3.7	11.5-12.4
28.0-30.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.4	1.9	0.3	0.4	0.1	0.0	0.0	0.0	3.5	12.5-13.4
30.2-32.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	1.3	0.2	0.2	0.1	0.0	0.0	0.0	2.2	13.5-14.4
32.4-34.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	1.0	0.1	0.1	0.0	0.0	0.0	0.0	1.5	14.5-15.4
34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.4	0.1	0.1	0.0	0.0	0.0	0.0	1.8	15.5-16.4
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	16.5-17.4
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.8	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.9	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.8	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.3	0.0	0.0	0.0	0.0	0.0	0.0	1.5	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
CALM																	1.7	CALM
TOTAL	3.2	2.1	5.0	10.0	5.4	1.3	0.7	1.2	6.9	24.7	15.7	13.3	5.6	0.8	1.2	1.0	99.8	TOTAL
AV SPD (MPH)	7.6	7.2	8.7	14.3	10.7	8.7	6.0	9.8	18.1	24.6	13.4	15.4	13.2	11.0	6.9	8.9	11.5	AV SPD (MPH)
AV SPD (M/S)	3.4	3.2	3.9	6.4	4.8	3.9	2.7	4.4	8.1	11.0	6.0	6.9	5.9	4.9	3.1	4.0	5.2	AV SPD (M/S)

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Figure IV - 14
Annual Wind Rose
LIVINGSTON FAA AIRPORT — PARK COUNTY
(1948 - 1953)





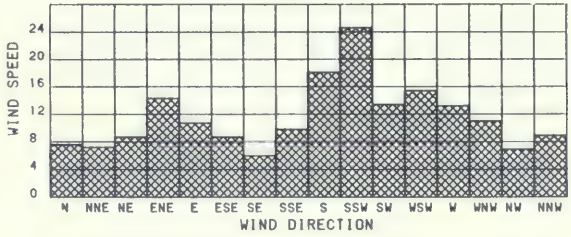


Table IV - 131

Coefficients of Weibull Distribution

PARK COUNTY - LIVINGSTON FAA AIRPORT

01/01/48 - 07/04/53

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	11.1560	1.7780
FEBRUARY	10.8990	1.8770
MARCH	8.6600	1.7670
APRIL	7.7930	2.0030
MAY	7.0240	2.0290
JUNE	6.9480	2.0310
JULY	5.8700	1.8800
AUGUST	6.3220	1.8550
SEPTEMBER	6.4940	2.0070
OCTOBER	8.1120	1.7030
NOVEMBER	10.2880	2.1010
DECEMBER	10.7900	1.9380
YEAR	8.4500	1.7660

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

HEART BUTTE
PONDERA COUNTY

The Heart Butte site is located over 3 miles west of Heart Butte and about 20 miles south of Browning at 48 17 42 N and 112 53 03 W (Site No. 100 on Map II-1). Elevation at the site is 5,161 feet. This monitoring site was part of the Wind Regional Energy Assessment Program run by Oregon State University for Bonneville Power Administration.

Well exposed and relatively smooth ridge crests abound in the area. The Rocky Mountain Front is less than 5 miles to the west. The site is representative of a large area. Access to the area is reasonable, with a state highway running to the east and a paved secondary road into Heart Butte. A number of dirt roads cut through the area. Winter access is sometimes hampered by drifting snow and severe weather conditions.

The site is located on the Blackfeet Indian Reservation. It is located south of Glacier National Park and near areas still being promoted for wilderness designation. Electrical service in the area is provided by the Glacier Electric Cooperative. One 115 kV line runs into Browning from Cut Bank. The area is at a remote end of the transmission system. The nearest commercial airport is located in Cut Bank, nearly 30 miles to the east. Air traffic generally is light.

Collection of wind data began in October 1981 when a wind-run anemometer was installed. Summaries of this data are printed in Appendix C. A data logger was installed and began collecting data on November 13, 1982. Data collection ran through May 29, 1984. The anemometer height was 35 feet.

Data recovery was fair to excellent, ranging from 68.8 percent in January to 100.0 percent in July through September. Overall data recovery was 92.3 percent.

Average monthly wind speeds ranged from 10.4 miles per hour in June to 27.5 miles per hour in January. Average annual wind speed was 18.0 miles per hour.

Average monthly wind power ranged from 113.9 watts/m^2 in June up to 1,753.8 watts/m^2 in January.

Average seasonal wind speeds were 12.6 miles per hour in the summer, 15.3 miles per hour in the autumn, 25.9 miles per hour in the winter, and 20.2 miles per hour in the spring. In the spring, highest winds happened in the afternoon. Diurnal range of average wind speeds was greatest in the spring, at 5.8 miles per hour and least in the autumn, with a range of 3.2 miles per hour. Highest speeds in winter were during the night.

The wind direction data is incomplete because the wind vane failed January 1, 1984 and was not replaced. The wind speeds during the following five months were particularly high. How this affected the distribution of the wind rose is not known; the wind speeds on the wind rose certainly are below what would have been the average for the eighteen-month monitoring period. The most common wind directions were west-southwest to north-northwest. Winds from the north-northeast through south-southeast were least common.

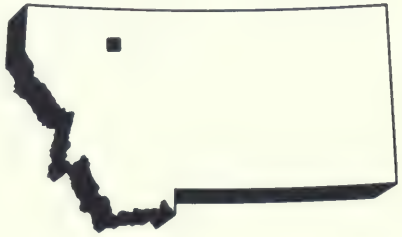


Table IV - 132

Monthly Wind Speed Distribution

PONDERA COUNTY - HEART BUTTE

11/13/82 - 05/29/84

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	0.8	1.2	0.0	1.0	0.0	2.5	0.3	0.7	4.4	1.5	3.5	6.7	1.8
0.1-1.0	0.7	1.2	0.0	0.6	0.0	2.0	1.2	1.2	3.3	2.2	2.5	5.0	1.6
1.1-2.0	0.0	0.7	0.0	0.4	0.0	4.0	2.6	1.9	1.7	2.1	3.0	3.9	1.5
2.1-3.0	6.5	7.4	1.5	10.1	7.4	5.6	3.0	2.6	2.6	2.8	3.4	4.4	4.8
3.1-4.0	0.7	0.5	0.8	1.1	0.0	6.1	3.5	2.8	2.4	3.2	3.4	4.7	2.2
4.1-5.0	1.4	0.6	1.5	1.9	0.3	6.1	3.8	3.8	1.9	2.7	3.5	4.7	2.4
5.1-6.0	2.1	0.9	1.1	2.6	0.9	5.6	5.2	5.0	3.3	2.7	3.9	3.6	2.9
6.1-7.0	1.8	1.3	3.2	2.6	0.6	5.6	3.6	4.4	2.9	3.2	4.0	4.4	3.0
7.1-8.0	2.0	1.7	3.5	3.7	0.6	7.6	3.2	6.3	3.2	5.2	3.6	3.9	3.4
8.1-9.0	1.5	1.6	3.5	3.4	1.3	4.5	4.7	8.1	4.4	4.5	4.9	4.1	3.8
9.1-10.0	1.9	2.3	4.2	3.2	1.8	6.1	5.9	7.0	4.2	4.8	3.8	4.7	4.0
10.1-11.0	1.4	2.0	3.2	3.7	2.8	7.1	6.7	7.0	4.0	4.1	3.7	5.0	4.0
11.1-12.0	1.5	2.6	3.9	4.0	1.5	6.6	5.2	6.9	4.4	4.8	2.7	2.9	3.7
12.1-13.0	1.5	1.6	3.1	4.4	3.6	3.5	5.8	7.7	5.1	3.8	3.3	3.6	3.9
13.1-14.0	2.1	1.9	3.8	3.6	3.6	4.0	3.9	5.6	4.7	3.1	3.2	2.3	3.4
14.1-15.0	1.9	1.7	3.1	4.5	2.4	3.0	4.4	5.6	2.9	4.1	2.2	2.8	3.2
15.1-16.0	1.4	2.4	3.6	4.2	1.6	2.5	3.6	3.5	2.4	5.5	2.8	2.4	3.0
16.1-17.0	1.8	1.6	5.0	3.4	2.7	1.5	5.0	4.2	3.5	3.5	3.4	1.1	3.2
17.1-18.0	1.4	1.7	4.7	3.0	2.7	2.5	3.5	3.6	2.5	4.8	4.1	1.6	3.1
18.1-19.0	2.0	2.1	4.8	3.0	2.1	2.5	3.5	3.2	4.0	4.9	3.0	1.8	3.1
19.1-20.0	1.8	2.6	3.5	2.5	3.6	1.5	2.4	2.3	4.3	4.5	1.8	2.0	2.7
20.1-25.0	7.5	11.5	15.0	13.1	13.5	7.6	9.4	5.1	15.3	13.3	10.3	7.0	10.9
25.1-30.0	9.3	13.1	10.5	8.7	15.8	1.0	5.1	0.8	6.3	4.8	9.8	5.4	8.1
30.1-35.0	6.5	13.5	4.7	6.2	11.1	0.5	3.1	0.5	3.1	0.8	5.3	4.9	5.4
35.1-40.0	5.9	4.8	4.3	2.5	7.1	0.5	0.7	0.1	1.4	0.3	1.5	2.0	2.7
>40.0	34.2	17.4	7.8	2.7	13.3	0.0	0.7	0.1	1.7	2.9	3.4	5.0	8.1
AVERAGE SPEED (MPH)	27.5	24.2	20.3	16.7	24.4	10.4	13.9	11.8	15.1	15.0	15.7	13.9	18.0
AVERAGE SPEED (M/SEC)	12.3	10.8	9.1	7.5	10.9	4.7	6.2	5.3	6.7	6.7	7.0	6.2	8.0
AVERAGE WIND POWER (WATTS/M**2)	1753.8	1196.3	697.6	456.4	1044.8	113.9	235.9	121.4	339.8	368.4	463.3	489.2	649.7
PERCENT DATA RECOVERY	68.8	81.4	97.1	97.3	98.8	91.7	100.0	100.0	100.0	95.8	98.3	94.8	92.3

SPEED (MPH)	SPEED (M/SEC)
CALM	
0.1- 0.4	
0.5- 0.9	
1.0- 1.3	
1.4- 1.8	
1.9- 2.2	
2.3- 2.7	
2.8- 3.1	
3.2- 3.6	
3.7- 4.0	
4.1- 4.5	
4.6- 4.9	
5.0- 5.4	
5.5- 5.8	
5.9- 6.3	
6.4- 6.7	
6.8- 7.2	
7.3- 7.6	
7.7- 8.0	
8.1- 8.5	
8.6- 8.9	
9.0-11.2	
11.3-13.4	
13.5-15.6	
15.7-17.9	
>17.9	

SMPH / MEISE / HOUR

ANEMOMETER HEIGHT = 11 METERS = 35 FEET
NUMBER OF OBSERVATIONS = 8830
PERCENTAGE DATA RECOVERY = 92.3

SOURCE: GEORESEARCH, INC.

Table IV - 133

Percentage Frequency Summary for Wind Speed

PONDERA COUNTY - HEART BUTTE

(WINTER)

11/13/82 - 05/29/84

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (METERS/SECOND)															
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	2.2	6.7	4.4	3.3	3.3	5.6	5.6	2.2	1.1	5.6	10.0	7.8	14.4	8.9	18.9	25.4	11.3
	2	2.4	2.4	7.3	2.4	2.4	0.0	7.3	6.1	2.4	0.0	7.3	7.3	8.5	12.2	6.1	25.6	25.9	11.6
	3	0.0	1.3	10.3	2.6	3.8	3.8	1.3	3.8	0.0	5.1	5.1	12.8	11.5	6.4	6.4	25.6	26.0	11.6
	4	0.0	2.7	8.0	1.3	5.3	2.7	4.0	1.3	1.3	4.0	1.3	16.0	6.7	17.3	5.3	22.7	26.5	11.8
	5	1.4	0.0	11.4	2.9	2.9	4.3	1.4	0.0	4.3	1.4	0.0	14.3	10.0	11.4	10.0	24.3	26.8	12.0
	6	1.4	4.3	7.2	2.9	1.4	1.4	1.4	1.4	2.9	5.8	4.3	13.0	8.7	8.7	4.3	30.4	26.9	12.0
	7	3.0	1.5	7.6	3.0	1.5	3.0	4.5	1.5	0.0	1.5	6.1	16.7	4.5	10.6	4.5	30.3	27.1	12.1
	8	1.6	1.6	9.4	1.6	4.7	3.1	1.6	1.6	0.0	6.3	6.3	6.3	9.4	12.5	9.4	25.0	26.7	11.9
H	9	0.0	1.6	9.5	4.8	4.8	1.6	1.6	1.6	3.2	7.9	1.6	9.5	9.5	12.7	4.8	25.4	26.0	11.6
	10	1.6	0.0	8.1	3.2	1.6	3.2	1.6	4.8	4.8	3.2	3.2	11.3	14.5	9.7	4.8	24.2	26.4	11.8
O	11	1.6	0.0	9.7	3.2	3.2	3.2	3.2	1.6	4.8	1.6	4.8	11.3	9.7	9.7	9.7	22.6	26.1	11.7
	12	1.6	0.0	6.5	3.2	3.2	3.2	4.8	4.8	1.6	3.2	3.2	11.3	11.3	11.3	3.2	27.4	26.5	11.8
U	13	2.2	1.1	6.7	4.5	10.1	3.4	6.7	3.4	2.2	1.1	3.4	10.1	11.2	10.1	5.6	18.0	22.9	10.2
	14	2.4	3.7	4.9	3.7	2.4	6.1	6.1	4.9	3.7	3.7	2.4	14.6	6.1	7.3	6.1	22.0	24.1	10.8
R	15	1.3	0.0	9.0	1.3	3.8	9.0	3.8	3.8	2.6	3.8	5.1	14.1	6.4	10.3	0.0	25.6	24.3	10.9
	16	1.3	0.0	6.5	1.3	5.2	5.2	2.6	2.6	10.4	5.2	2.6	10.4	7.8	11.7	6.5	20.8	25.1	11.2
	17	0.0	1.4	7.2	1.4	2.9	4.3	4.3	5.8	7.2	2.9	1.4	8.7	8.7	13.0	10.1	20.3	25.8	11.5
	18	1.5	1.5	5.9	0.0	0.0	4.4	1.5	5.9	8.8	1.5	8.8	14.7	8.8	7.4	8.8	20.6	25.8	11.5
	19	0.0	1.5	5.9	2.9	1.5	4.4	1.5	4.4	8.8	2.9	2.9	17.6	7.4	10.3	2.9	25.0	25.8	11.5
	20	0.0	1.5	4.4	4.4	1.5	1.5	4.4	5.9	4.4	2.9	8.8	11.8	8.8	10.3	5.9	23.5	26.2	11.7
	21	0.0	1.5	6.0	3.0	3.0	3.0	4.5	3.0	4.5	4.5	3.0	11.9	10.4	16.4	3.0	22.4	26.0	11.6
	22	0.0	0.0	10.4	1.5	0.0	4.5	4.5	6.0	3.0	3.0	1.5	13.4	11.9	10.4	9.0	20.9	26.4	11.8
	23	0.0	0.0	7.8	0.0	3.1	3.1	4.7	4.7	3.1	4.7	7.8	9.4	9.4	9.4	7.8	25.0	27.1	12.1
	24	0.0	0.0	6.5	0.0	8.1	6.5	4.8	0.0	4.8	3.2	4.8	3.2	9.7	21.0	0.0	27.4	26.8	12.0
ALL HOURS		1.0	1.3	7.6	2.5	3.4	3.7	3.8	3.6	3.8	3.3	4.2	11.7	9.0	11.4	6.0	23.7	25.9	11.6

SOURCE: GEORESEARCH, INC.

Table IV - 134

Percentage Frequency Summary for Wind Speed

PONDERA COUNTY - HEART BUTTE

(SPRING)

11/13/82 - 05/29/84

		WIND SPEED (MPH)																	
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	1.0	8.2	4.1	6.2	8.2	7.2	5.2	6.2	10.3	6.2	12.4	6.2	5.2	7.2	6.2	19.1	8.5
	2	0.0	1.0	7.2	4.1	2.1	9.3	13.4	7.2	4.1	4.1	6.2	17.5	7.2	7.2	2.1	7.2	19.1	8.5
	3	1.1	0.0	7.4	4.2	6.3	9.5	8.4	7.4	5.3	4.2	6.3	15.8	8.4	8.4	3.2	4.2	18.4	8.2
	4	1.1	0.0	9.5	5.3	6.3	7.4	4.2	9.5	3.2	10.5	4.2	15.8	8.4	8.4	1.1	5.3	18.1	8.1
	5	1.1	1.1	9.6	4.3	10.6	5.3	4.3	8.5	4.3	7.4	3.2	16.0	8.5	6.4	4.3	5.3	18.3	8.2
	6	2.1	0.0	10.6	9.6	6.4	8.5	2.1	9.6	4.3	3.2	4.3	18.1	6.4	5.3	4.3	5.3	17.5	7.8
	7	2.1	0.0	11.7	8.5	7.4	8.5	4.3	5.3	0.0	10.6	4.3	12.8	7.4	11.7	1.1	4.3	17.3	7.7
	8	1.1	1.1	10.6	3.2	11.7	5.3	8.5	4.3	3.2	7.4	4.3	14.9	9.6	5.3	4.3	5.3	17.9	8.0
H	9	0.0	1.1	9.6	4.3	7.4	7.4	6.4	6.4	6.4	4.3	7.4	16.0	10.6	4.3	0.0	8.5	18.3	8.2
	10	0.0	0.0	8.5	0.0	2.1	9.6	9.6	4.3	7.4	9.6	6.4	20.2	9.6	4.3	2.1	6.4	19.6	8.8
O	11	0.0	0.0	6.5	1.1	4.3	7.5	3.2	7.5	3.2	10.8	7.5	24.7	10.8	2.2	4.3	6.5	20.5	9.2
	12	0.0	0.0	5.4	1.1	2.2	3.3	5.4	7.6	6.5	9.8	6.5	26.1	12.0	7.6	1.1	5.4	21.1	9.4
U	13	0.0	0.0	5.3	1.1	1.1	3.2	6.3	9.5	6.3	3.2	12.6	16.8	14.7	10.5	4.2	5.3	22.1	9.9
	14	0.0	0.0	5.3	1.1	2.1	2.1	5.3	6.3	7.4	5.3	10.5	15.8	16.8	10.5	5.3	6.3	22.8	10.2
R	15	0.0	0.0	6.3	0.0	1.1	2.1	6.3	8.4	6.3	4.2	7.4	17.9	14.7	14.7	2.1	8.4	23.1	10.3
	16	0.0	0.0	6.3	1.1	3.2	0.0	4.2	7.4	10.5	3.2	7.4	21.1	9.5	15.8	3.2	7.4	22.9	10.3
	17	0.0	0.0	5.3	2.1	2.1	1.1	4.2	7.4	9.5	8.4	8.4	14.7	9.5	11.6	7.4	8.4	23.0	10.3
	18	0.0	0.0	4.3	1.1	3.2	2.1	4.3	9.6	9.6	9.6	6.4	16.0	10.6	7.4	10.6	5.3	22.4	10.0
	19	0.0	0.0	5.3	1.1	2.1	6.4	11.7	7.4	6.4	10.6	4.3	10.6	9.6	8.5	9.6	6.4	21.6	9.7
	20	0.0	0.0	4.3	0.0	7.4	4.3	7.4	9.6	12.8	3.2	7.4	10.6	10.6	7.4	9.6	5.3	21.2	9.5
	21	0.0	0.0	5.3	2.1	6.4	5.3	5.3	7.4	13.8	8.5	5.3	9.6	8.5	7.4	8.5	6.4	20.7	9.2
	22	0.0	1.1	5.3	3.2	3.2	6.4	11.7	6.4	9.6	9.6	5.3	5.3	9.6	9.6	3.2	10.6	20.6	9.2
	23	0.0	1.1	6.4	2.1	7.4	8.5	5.3	7.4	5.3	8.5	8.5	12.8	5.3	7.4	5.3	8.5	20.1	9.0
	24	0.0	1.1	6.6	4.4	5.5	11.0	6.6	6.6	7.7	5.5	4.4	15.4	4.4	4.4	7.7	8.8	19.5	8.7
ALL HOURS		0.4	0.4	7.1	2.9	4.9	5.9	6.5	7.3	6.6	7.2	6.5	15.7	9.5	8.0	4.6	6.5	20.2	9.0

SOURCE: GEORESEARCH, INC.

Table IV - 135

Percentage Frequency Summary for Wind Speed

PONDERA COUNTY - HEART BUTTE

(SUMMER)

11/13/82 - 05/29/84

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (METERS/SECOND)															
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	4.2	2.8	7.0	8.5	19.7	18.3	7.0	9.9	8.5	4.2	7.0	0.0	1.4	1.4	0.0	12.5	5.6
	2	0.0	4.2	5.6	4.2	12.7	19.7	15.5	8.5	7.0	2.8	5.6	8.5	2.8	2.8	0.0	0.0	12.5	5.6
	3	0.0	7.0	7.0	14.1	8.5	9.9	12.7	14.1	4.2	8.5	2.8	7.0	0.0	4.2	0.0	0.0	11.8	5.3
	4	0.0	7.0	8.5	9.9	9.9	8.5	16.9	16.9	1.4	4.2	4.2	7.0	2.8	1.4	1.4	0.0	11.9	5.3
	5	1.4	5.7	5.7	10.0	14.3	11.4	11.4	11.4	4.3	4.3	8.6	8.6	0.0	0.0	1.4	1.4	11.9	5.3
	6	1.4	5.8	10.1	17.4	4.3	10.1	8.7	11.6	10.1	7.2	1.4	7.2	1.4	1.4	0.0	1.4	11.6	5.2
	7	1.4	13.0	7.2	11.6	14.5	8.7	8.7	8.7	5.8	5.8	2.9	7.2	1.4	1.4	1.4	0.0	10.9	4.9
	8	1.4	10.1	11.6	15.9	11.6	7.2	13.0	4.3	4.3	4.3	4.3	7.2	1.4	1.4	1.4	0.0	10.4	4.7
H	9	2.9	1.4	17.4	15.9	15.9	10.1	7.2	2.9	7.2	4.3	2.9	7.2	1.4	1.4	1.4	0.0	10.3	4.6
	10	0.0	2.9	13.0	15.9	11.6	7.2	11.6	7.2	7.2	5.8	8.7	7.2	0.0	1.4	0.0	0.0	11.2	5.0
O	11	0.0	2.9	10.1	14.5	8.7	13.0	4.3	4.3	8.7	13.0	4.3	13.0	1.4	1.4	0.0	0.0	12.4	5.6
	12	1.4	1.4	8.7	10.1	10.1	14.5	4.3	13.0	5.8	10.1	5.8	11.6	0.0	2.9	0.0	0.0	12.6	5.6
U	13	0.0	4.2	5.6	8.5	8.5	8.5	14.1	9.9	8.5	7.0	14.1	9.9	1.4	0.0	0.0	0.0	13.1	5.8
	14	0.0	1.4	4.2	8.5	9.9	8.5	14.1	4.2	9.9	9.9	9.9	14.1	5.6	0.0	0.0	0.0	14.3	6.4
R	15	2.8	1.4	5.6	8.5	7.0	9.9	8.5	2.8	5.6	14.1	12.7	15.5	5.6	0.0	0.0	0.0	14.4	6.4
	16	0.0	1.4	7.0	9.9	8.5	2.8	4.2	16.9	14.1	15.5	7.0	11.3	1.4	0.0	0.0	0.0	13.8	6.2
	17	1.4	0.0	8.5	1.4	8.5	9.9	14.1	7.0	21.1	11.3	4.2	9.9	2.8	0.0	0.0	0.0	13.6	6.1
	18	1.4	1.4	1.4	4.2	4.2	14.1	16.9	16.9	14.1	8.5	7.0	5.6	1.4	2.8	0.0	0.0	13.8	6.2
	19	1.4	1.4	2.8	5.6	4.2	19.7	12.7	19.7	12.7	9.9	1.4	1.4	4.2	2.8	0.0	0.0	13.1	5.9
	20	0.0	1.4	1.4	2.8	11.3	16.9	22.5	14.1	8.5	4.2	2.8	7.0	2.8	4.2	0.0	0.0	13.6	6.1
	21	0.0	1.4	5.6	5.6	4.2	15.5	23.9	11.3	7.0	7.0	4.2	5.6	1.4	7.0	0.0	0.0	13.8	6.2
	22	0.0	5.7	1.4	8.6	7.1	14.3	15.7	20.0	5.7	8.6	4.3	4.3	1.4	1.4	1.4	0.0	12.7	5.7
	23	0.0	0.0	4.3	8.6	11.4	21.4	14.3	12.9	7.1	5.7	5.7	5.7	0.0	1.4	1.4	0.0	12.5	5.6
	24	0.0	4.3	2.9	2.9	8.6	20.0	17.1	18.6	7.1	2.9	2.9	10.0	0.0	2.9	0.0	0.0	13.0	5.8
ALL HOURS		0.7	3.7	6.6	9.2	9.3	12.6	13.0	11.0	8.2	7.7	5.5	8.3	1.7	1.8	0.5	0.1	12.6	5.6

SOURCE: GEORESEARCH, INC.

Table IV - 136

Percentage Frequency Summary for Wind Speed

PONDERA COUNTY - HEART BUTTE

(AUTUMN)

11/13/82 - 05/29/84

		WIND SPEED (MPH)																	
			0.1-	2.1-	4.1-	6.1-	8.1-	10.1-	12.1-	14.1-	16.1-	18.1-	20.1-	25.1-	30.1-	35.1-			
		CALM	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	35.0	40.0	>40.0		
			WIND SPEED (METERS/SECOND)																
			0.1-	0.9-	1.8-	2.7-	3.6-	4.5-	5.4-	6.3-	7.2-	8.1-	9.0-	11.2-	13.5-	15.7-		AV	AV
		CALM	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.0	8.9	11.2	13.4	15.6	17.9	>17.9	SPEED (MPH)	SPEED (M/SEC)
	1	4.6	5.5	4.6	6.4	9.2	11.0	8.3	9.2	7.3	7.3	1.8	12.8	4.6	4.6	0.9	1.8	14.5	6.5
	2	2.8	5.5	6.4	8.3	10.1	7.3	8.3	8.3	6.4	5.5	4.6	13.8	6.4	3.7	0.9	1.8	14.6	6.5
	3	3.7	3.7	6.4	6.4	12.8	7.3	7.3	7.3	5.5	6.4	6.4	15.6	4.6	4.6	0.9	0.9	14.6	6.5
	4	5.5	2.8	8.3	6.4	8.3	11.9	4.6	5.5	4.6	9.2	7.3	14.7	5.5	2.8	0.9	1.8	14.6	6.5
	5	5.5	3.7	8.3	2.8	10.1	11.0	5.5	3.7	11.9	4.6	7.3	15.6	7.3	1.8	0.0	0.9	14.3	6.4
	6	2.8	6.5	6.5	9.3	8.3	10.2	10.2	7.4	2.8	3.7	7.4	13.0	6.5	2.8	0.9	1.9	14.2	6.4
	7	3.7	6.5	8.3	11.1	6.5	10.2	13.0	2.8	8.3	4.6	1.9	8.3	8.3	3.7	0.9	1.9	13.7	6.1
	8	6.5	9.3	7.4	7.4	7.4	5.6	2.8	12.0	5.6	5.6	3.7	16.7	5.6	1.9	0.9	1.9	13.7	6.1
H	9	2.8	9.3	11.2	5.6	4.7	5.6	10.3	8.4	0.9	10.3	7.5	13.1	1.9	5.6	0.0	2.8	14.2	6.4
	10	4.7	6.6	3.8	6.6	7.5	6.6	6.6	9.4	7.5	8.5	9.4	12.3	5.7	1.9	0.9	1.9	14.8	6.6
O	11	1.0	5.7	6.7	4.8	4.8	10.5	7.6	7.6	6.7	12.4	4.8	12.4	8.6	3.8	1.0	1.9	15.8	7.1
	12	0.0	6.0	8.0	3.0	5.0	13.0	5.0	7.0	7.0	12.0	6.0	19.0	1.0	3.0	2.0	3.0	15.8	7.1
U	13	0.9	3.7	6.5	4.6	6.5	6.5	8.3	10.2	6.5	6.5	7.4	21.3	4.6	3.7	0.9	1.9	16.1	7.2
	14	1.9	4.6	4.6	6.5	4.6	9.3	5.6	5.6	9.3	7.4	13.0	14.8	5.6	4.6	0.9	1.9	16.2	7.2
R	15	0.9	2.8	6.5	6.5	5.6	6.5	4.6	6.5	9.3	7.4	18.5	13.9	3.7	4.6	0.9	1.9	16.4	7.4
	16	0.9	2.8	4.6	4.6	3.7	5.6	9.3	10.2	5.6	13.0	16.7	11.1	3.7	4.6	0.9	2.8	16.9	7.6
	17	0.9	3.7	1.9	1.9	10.2	9.3	11.1	9.3	10.2	9.3	6.5	13.9	3.7	4.6	0.0	3.7	16.3	7.3
	18	1.9	1.9	1.9	5.6	9.3	11.1	11.1	12.0	4.6	9.3	4.6	13.0	6.5	1.9	0.9	4.6	16.2	7.2
	19	0.0	2.8	6.5	11.1	5.6	13.9	7.4	6.5	6.5	3.7	8.3	12.0	4.6	5.6	0.9	4.6	16.0	7.1
	20	4.6	5.6	8.3	7.4	5.6	8.3	10.2	2.8	3.7	5.6	7.4	15.7	1.9	6.5	0.9	5.6	15.9	7.1
	21	5.6	5.6	7.4	2.8	11.1	5.6	6.5	7.4	2.8	6.5	2.8	18.5	5.6	4.6	1.9	5.6	16.4	7.3
	22	4.7	4.7	5.6	7.5	6.5	9.3	7.5	4.7	5.6	5.6	5.6	16.8	8.4	4.7	0.0	2.8	15.7	7.0
	23	5.9	5.9	2.9	8.8	5.9	9.8	3.9	7.8	6.9	4.9	4.9	14.7	9.8	2.9	2.0	2.9	15.9	7.1
	24	6.2	6.2	3.1	4.1	8.2	6.2	9.3	9.3	7.2	6.2	5.2	15.5	7.2	3.1	1.0	2.1	15.2	6.8
ALL HOURS		3.2	5.0	6.1	6.2	7.4	8.8	7.7	7.5	6.4	7.3	7.1	14.5	5.5	3.8	0.9	2.6	15.3	6.9

SOURCE: GEORESEARCH, INC.

Table IV - 137

Annual Wind Rose Distribution

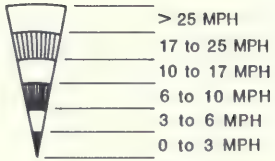
PONDERA COUNTY - HEART BUTTE

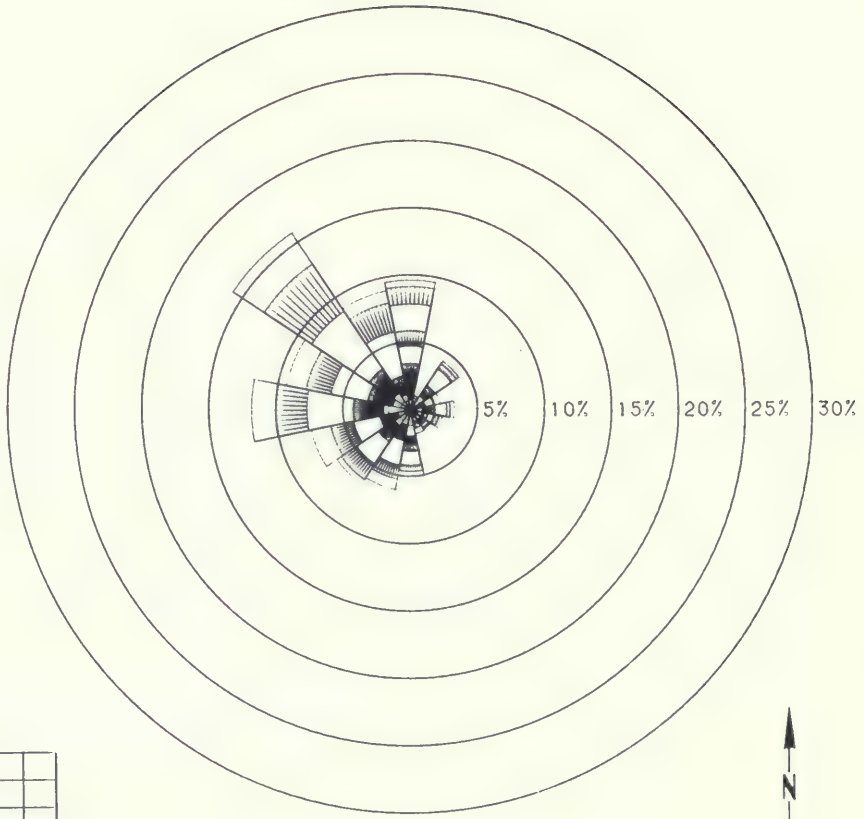
11/13/82 - 05/29/84

DIRECTION> / SPEED (MPH)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION / SPEED (M/SEC)
0.1- 1.0	0.2	0.1	0.2	0.2	0.3	0.2	0.1	0.1	0.3	0.1	0.2	0.2	0.1	0.2	0.2	0.1	2.7	0.1- 0.4
1.1- 2.0	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.2	2.6	0.5- 0.9
2.1- 3.0	0.4	0.1	0.2	0.1	0.1	0.2	0.2	0.1	0.3	0.3	0.2	0.2	0.4	0.2	0.2	0.2	3.3	1.0- 1.3 S
3.1- 4.0	0.2	0.1	0.2	0.1	0.1	0.2	0.3	0.1	0.3	0.2	0.3	0.2	0.4	0.2	0.2	0.2	3.3	1.4- 1.8 P
S 4.1- 5.0	0.3	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.5	0.2	0.3	0.2	3.4	1.9- 2.2 E
P 5.1- 6.0	0.4	0.1	0.3	0.1	0.2	0.1	0.2	0.2	0.5	0.3	0.3	0.1	0.5	0.3	0.3	0.2	4.0	2.3- 2.7 E
E 6.1- 7.0	0.3	0.0	0.2	0.1	0.2	0.0	0.1	0.1	0.3	0.3	0.3	0.3	0.5	0.3	0.3	0.3	3.8	2.8- 3.1 D
E 7.1- 8.0	0.2	0.0	0.2	0.0	0.3	0.2	0.1	0.1	0.3	0.3	0.3	0.4	0.5	0.5	0.6	0.3	4.3	3.2- 3.6
D 8.1- 9.0	0.4	0.0	0.3	0.2	0.1	0.2	0.1	0.2	0.3	0.2	0.5	0.3	0.5	0.4	0.6	0.4	4.9	3.7- 4.0 M
9.1-10.0	0.3	0.0	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.6	0.7	0.6	0.5	4.8	4.1- 4.5 E
M 10.1-11.0	0.2	0.1	0.4	0.2	0.2	0.0	0.1	0.1	0.2	0.2	0.4	0.3	0.8	0.6	0.7	0.4	4.8	4.6- 4.9 T
I 11.1-12.0	0.3	0.0	0.2	0.1	0.1	0.1	0.0	0.1	0.2	0.3	0.3	0.3	0.5	0.3	0.7	0.6	4.3	5.0- 5.4 E
L 12.1-13.0	0.3	0.1	0.2	0.2	0.2	0.1	0.0	0.1	0.2	0.3	0.3	0.4	0.5	0.4	0.8	0.6	4.6	5.5- 5.8 R
E 13.1-14.0	0.4	0.0	0.3	0.1	0.1	0.1	0.0	0.1	0.1	0.2	0.3	0.3	0.2	0.3	0.9	0.4	3.9	5.9- 6.3 S
S 14.1-15.0	0.3	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.3	0.2	0.2	0.5	0.3	0.7	0.5	3.5	6.4- 6.7 /
/ 15.1-16.0	0.2	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.4	0.3	0.5	0.5	0.7	0.4	3.4	6.8- 7.2 S
H 16.1-17.0	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.4	0.3	0.7	0.5	3.4	7.3- 7.6 E
O 17.1-18.0	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.3	0.4	0.4	0.4	0.8	0.4	3.4	7.7- 8.0 C
U 18.1-19.0	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.2	0.4	0.2	0.5	0.2	0.8	0.4	3.3	8.1- 8.5 O
R 19.1-20.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.2	0.2	0.4	0.4	0.7	0.3	2.8	8.6- 8.9 N
20.1-25.0	0.6	0.1	0.2	0.1	0.2	0.2	0.0	0.0	0.2	0.8	0.6	1.1	1.2	1.1	2.4	1.3	10.0	9.0-11.2 D
25.1-30.0	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.2	0.6	0.2	0.6	0.7	0.8	1.3	0.4	5.8	11.3-13.4
30.1-35.0	0.2	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.6	0.6	0.4	0.6	0.3	3.3	13.5-15.6
35.1-40.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.2	0.4	0.1	1.4	15.7-17.9
>40.0	0.1	0.0	0.0	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.1	0.1	0.3	2.1	>17.9
CALM																	3.0	CALM
TOTAL	6.7	1.2	4.4	2.8	3.3	2.5	1.8	1.8	5.0	6.0	6.6	8.1	12.1	9.5	16.0	9.3	100.0	TOTAL
AV SPEED (MPH)	13.4	12.4	11.3	19.7	11.5	13.2	8.2	7.1	10.6	13.9	12.7	18.5	15.7	15.6	16.9	16.1	14.4	AV SPEED (MPH)
AV SPEED (M/SEC)	6.0	5.5	5.1	8.8	5.2	5.9	3.7	3.2	4.7	6.2	5.7	8.3	7.0	7.0	7.6	7.2	6.4	AV SPEED (M/SEC)

SOURCE: GEORESEARCH, INC.

Figure IV - 15
Annual Wind Rose
PONDERA COUNTY - HEART BUTTE
(1982 - 1984)





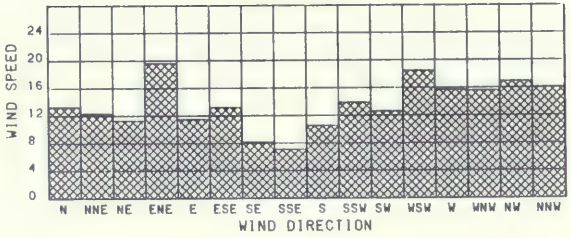


Table IV - 138

Coefficients of Weibull Distribution

PONDERA COUNTY - HEART BUTTE

11/13/82 - 05/29/84

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	16.7163	1.4883
FEBRUARY	13.8343	1.6648
MARCH	9.6070	1.9676
APRIL	8.5469	1.5470
MAY	12.9609	2.0039
JUNE	5.1221	1.5909
JULY	6.8428	1.7648
AUGUST	5.8349	2.2495
SEPTEMBER	8.0830	1.7133
OCTOBER	7.5162	1.8382
NOVEMBER	8.1650	1.3627
DECEMBER	6.8367	1.1526
YEAR	8.9803	1.4585

SOURCE: GEORESEARCH, INC.

BROADUS RANDALL RANCH

POWDER RIVER COUNTY

The Randall Ranch air monitoring site was established by the Montana Air Quality Bureau to measure background levels of particulates in southeastern Montana. The site was located at 45 24 27 N and 105 27 50 W (Site No. 102 on Map II-1), approximately 5 miles south of Broadus on a bluff overlooking the Powder River. Elevation at the site was 3,120 feet.

Wind data were gathered at this site from March 6, 1976, to August 27, 1978. The data set contains hourly averages of wind speed and wind direction manually reduced from stripchart records. The wind recorder, a Meteorology Research, Inc., mechanical recording anemometer and wind vane, was located 4 meters above ground level.

Winds were monitored long enough to adequately represent the wind resource at this location. The site also is representative of a large portion of southeastern Montana. Data recovery, which for the entire period was 60.3 percent, ranged from 38.4 percent in December to 97.3 percent in May.

Average monthly wind speeds varied from 8.2 miles per hour in September to 12.5 miles per hour in December. Average annual wind speed was 10.1 miles per hour. December through May were the windiest months. The lowest wind speeds occurred from July through September.

Average annual wind power was 118.9 watts/m^2. Average monthly wind power values ranged from 67.6 watts/m^2 in September to 167.7 watts/m^2 in December.

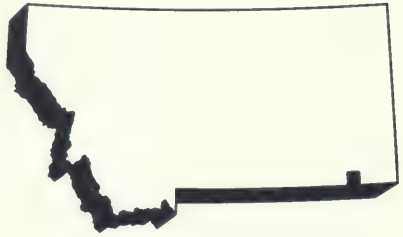


Table IV - 139

Monthly Wind Speed Distribution

POWDER RIVER COUNTY - BROADUS RANDALL RANCH

03/06/76 - 08/27/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.1	0.0	0.0	0.1	0.0	0.3	0.3	0.7	0.2	0.0	0.0	0.0	0.2	0.1- 0.4
1.1-2.0	2.7	0.7	1.0	1.1	1.3	2.6	2.1	3.0	2.6	2.8	2.0	0.3	1.8	0.5- 0.9
2.1-3.0	8.5	1.6	2.8	4.3	4.0	4.9	5.0	5.4	6.9	5.4	5.0	0.9	4.6	1.0- 1.3
3.1-4.0	9.6	4.2	6.6	4.7	6.0	8.0	6.1	6.9	8.1	6.4	7.7	1.4	6.3	1.4- 1.8
4.1-5.0	4.7	4.2	8.3	6.3	7.2	7.0	8.6	7.8	10.4	8.7	7.5	3.3	7.2	1.9- 2.2
5.1-6.0	7.0	6.1	7.8	6.2	6.2	8.1	8.3	9.6	10.1	6.4	5.9	2.8	7.2	2.3- 2.7
6.1-7.0	5.8	4.2	6.1	6.7	7.4	9.0	10.8	8.7	10.5	8.7	6.4	6.6	7.7	2.8- 3.1
7.1-8.0	5.3	5.7	4.8	6.5	6.5	8.3	8.9	8.3	7.2	9.4	7.0	6.3	7.1	3.2- 3.6
8.1-9.0	5.1	5.7	6.8	6.0	6.1	6.9	10.2	10.0	7.4	9.9	6.0	6.5	7.2	3.7- 4.0
9.1-10.0	6.5	5.7	6.2	5.7	6.0	6.9	6.9	7.6	5.2	7.2	5.5	6.6	6.3	4.1- 4.5
10.1-11.0	3.8	6.0	6.5	5.4	5.2	5.7	6.3	7.0	5.0	5.7	6.2	5.4	5.7	4.6- 4.9
11.1-12.0	4.6	7.3	6.3	5.0	5.5	5.8	4.4	3.8	4.8	4.7	6.9	8.6	5.4	5.0- 5.4
12.1-13.0	2.6	7.3	3.9	3.9	5.3	4.4	5.2	3.7	3.9	3.9	5.4	7.3	4.6	5.5- 5.8
13.1-14.0	4.2	4.8	3.4	4.4	5.0	4.0	3.4	3.1	2.9	3.1	5.5	5.2	4.1	5.9- 6.3
14.1-15.0	4.9	6.1	3.4	5.3	4.2	3.8	3.2	2.5	2.5	3.3	2.8	7.3	4.1	6.4- 6.7
15.1-16.0	4.1	5.8	3.7	4.3	3.8	2.4	2.0	2.7	2.7	3.7	4.4	3.5	3.5	6.8- 7.2
16.1-17.0	3.7	4.6	3.6	3.8	3.3	2.4	2.2	1.6	1.8	2.2	2.5	5.2	3.0	7.3- 7.6
17.1-18.0	3.4	4.8	2.6	3.5	2.4	2.1	1.6	2.2	2.2	1.1	1.7	3.5	2.6	7.7- 8.0
18.1-19.0	3.0	3.3	2.4	2.4	2.3	2.0	1.5	1.0	1.1	2.4	3.5	4.0	2.3	8.1- 8.5
19.1-20.0	2.0	2.7	1.9	1.9	2.2	1.2	0.7	1.0	0.6	0.3	2.8	3.3	1.7	8.6- 8.9
20.1-25.0	6.0	8.2	7.7	8.7	6.8	3.4	1.5	2.0	3.2	3.1	3.7	10.0	5.5	9,0-11.2
25.1-30.0	1.6	1.2	3.4	3.4	2.1	0.9	0.3	0.9	0.4	1.2	1.3	1.7	1.7	11.3-13.4
30.1-35.0	0.5	0.1	0.7	0.5	0.9	0.0	0.2	0.2	0.2	0.4	0.2	0.0	0.4	13.5-15.6
35.1-40.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	10.1	11.9	11.0	11.4	10.8	9.0	8.5	8.5	8.2	9.0	9.9	12.5	10.1	
AVERAGE SPEED (M/SEC)	4.5	5.3	4.9	5.1	4.8	4.0	3.8	3.8	3.7	4.0	4.4	5.6	4.5	
AVERAGE WIND POWER (WATTS/M**2)	136.7	153.6	163.6	163.4	144.0	80.8	75.0	70.3	67.6	85.8	107.6	167.7	118.9	
PERCENT DATA RECOVERY	49.6	50.0	42.6	93.9	97.3	66.7	52.1	55.2	62.3	49.5	41.5	38.4	60.3	

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
NUMBER OF OBSERVATIONS = 13092
PERCENTAGE DATA RECOVERY = 60.3

SOURCE: GEORESEARCH, INC.

SPEED (MPH) / SPEED (M/SEC)

COLSTRIP BN

ROSEBUD COUNTY

The Colstrip BN air monitoring site was established by the Montana Air Quality Bureau to measure concentrations of particulates, sulfur dioxide, and nitrogen dioxide in the air at Colstrip. The site was located approximately 2 miles southeast of Colstrip on top of an isolated hill at 45 51 30 N and 106 34 43 W (Site No. 109 on Map II-1). Elevation at the site was 3,575 feet.

The land in the area is hilly, with isolated steep-sided bluffs rising above the stream valleys. About 10 miles to the south, a steep escarpment rises abruptly to around 4,500 feet.

Although most of the land in the area is privately owned, a few scattered sections are controlled by the state and the Bureau of Land Management. The Northern Cheyenne Indian Reservation lies about 12 miles to the south.

Electrical power in the area is provided by the Montana Power Company and the Tongue River Electric Cooperative. Because Colstrip is a major electrical generation center, many electrical transmission lines cross the area.

Wind data were gathered at the site from January 1, 1975, to August 22, 1979. The wind recorder was a Meteorology Research, Inc., mechanical recording anemometer and wind vane located 4 meters above ground level. The data set consists of hourly averages of wind speed and wind direction. Data recovery was poor to fair, ranging from 11.3 percent in November to 78.2 percent in September. Overall data recovery was 39.5 percent.

Winds were monitored long enough, however, to represent the wind resource at this location. The data also are representative of other open, exposed, and elevated locations in the southern Rosebud County area.

Average annual wind speed at this site was 12.9 miles per hour. Average monthly speeds varied from 9.6 miles per hour in September to 16.8 miles per hour in February. The windiest months were January through April. The lowest wind speeds occurred during the months of July through September.

Average monthly wind power ranged from 205.7 watts/m² in July to 818.1 watts/m² in February. Average annual wind power was 453.6 watts/m².

Average seasonal wind speeds were 11.0 miles per hour in autumn, 11.3 miles per hour in summer, 13.6 miles per hour in spring, and 16.2 miles per hour in winter. The highest average wind speeds occurred during the mid-afternoon in spring and autumn, early evening in summer, and early morning and mid-afternoon in winter. The lowest average wind speeds occurred in early morning during the summer, in early evening during the autumn and winter, and in early morning and early evening during the spring.

The diurnal range of average wind speeds was greatest in spring and summer and least in winter.

The most common wind directions were west and west-northwest. Winds from the north-northeast and northeast were least common. By direction, average wind speeds varied from 8.6 miles per hour for winds blowing from the east-northeast to 17.2 miles per hour for westerly winds.

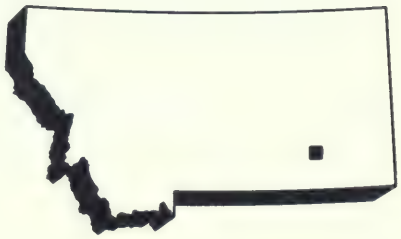


Table IV - 140

Monthly Wind Speed Distribution

ROSEBUD COUNTY - COLSTRIP BN

01/01/75 - 08/22/79

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	SPEED (M/SEC)
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	4.3	0.0	0.0	0.0	0.8	CALM
0.1-1.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	4.0	5.2	0.1	0.0	0.1	1.2	0.1- 0.4
1.1-2.0	0.4	0.3	0.6	0.2	0.2	0.2	0.4	5.0	6.1	0.5	0.0	1.5	1.7	0.5- 0.9
2.1-3.0	0.9	0.8	1.5	1.2	1.3	2.6	1.6	1.2	1.9	1.9	0.0	3.9	1.6	1.0- 1.3
3.1-4.0	1.4	1.8	2.1	2.4	4.2	5.7	3.7	1.7	3.1	3.7	1.2	4.2	3.1	1.4- 1.8
4.1-5.0	1.7	2.6	3.3	3.4	5.7	5.2	4.9	2.8	5.3	4.2	2.8	5.2	4.1	1.9- 2.2
5.1-6.0	3.3	3.2	5.3	2.2	5.8	5.8	7.9	4.3	6.1	4.5	3.4	6.4	5.1	2.3- 2.7
6.1-7.0	3.1	3.5	3.9	4.1	6.3	6.3	8.3	5.3	5.9	6.7	2.8	6.4	5.5	2.8- 3.1
7.1-8.0	2.9	3.3	5.7	3.6	6.2	5.3	6.4	6.3	6.8	5.9	4.0	5.3	5.5	3.2- 3.6
8.1-9.0	3.6	3.6	5.5	5.8	7.0	5.9	8.4	6.0	6.4	6.5	7.1	4.5	5.9	3.7- 4.0
9.1-10.0	4.0	4.1	5.7	6.3	6.2	7.1	8.7	6.1	7.3	6.4	4.9	4.5	6.1	4.1- 4.5
10.1-11.0	4.5	3.6	4.9	4.8	5.2	5.2	7.5	6.1	6.5	5.7	7.4	4.0	5.5	4.6- 4.9
11.1-12.0	5.0	4.6	4.0	3.4	5.3	5.6	6.4	6.2	5.3	5.6	8.3	3.4	5.3	5.0- 5.4
12.1-13.0	4.4	4.4	4.4	5.3	5.7	5.7	5.2	5.3	3.5	5.4	6.2	4.0	4.9	5.5- 5.8
13.1-14.0	5.5	3.3	4.2	4.1	4.9	5.2	5.6	4.4	3.5	5.5	8.0	1.3	4.5	5.9- 6.3
14.1-15.0	5.7	4.0	4.9	3.4	4.9	4.0	5.3	3.6	2.6	4.8	4.9	2.2	4.2	6.4- 6.7
15.1-16.0	6.3	4.1	3.3	4.3	5.5	3.8	4.2	3.7	2.7	4.9	5.9	3.4	4.2	6.8- 7.2
16.1-17.0	4.3	4.6	4.2	4.9	3.9	3.4	4.1	4.3	2.4	4.3	2.2	2.8	3.8	7.3- 7.6
17.1-18.0	5.3	4.1	3.1	2.7	3.8	3.8	1.5	3.1	2.2	2.7	4.9	2.5	3.2	7.7- 8.0
18.1-19.0	3.8	4.3	4.5	3.6	2.7	2.4	2.3	3.4	1.5	4.1	4.0	3.1	3.1	8.1- 8.5
19.1-20.0	3.3	4.3	3.3	2.0	2.3	3.8	1.2	2.4	1.2	3.0	2.5	2.2	2.6	8.6- 8.9
20.1-25.0	14.8	17.8	13.6	21.1	8.1	10.2	4.9	8.9	6.3	9.4	12.0	14.4	10.7	9,0-11.2
25.1-30.0	8.4	11.2	7.0	7.3	2.5	2.0	1.0	1.9	2.3	2.4	4.3	7.7	4.3	11.3-13.4
30.1-35.0	4.5	3.5	2.9	2.4	1.0	0.6	0.2	1.1	1.0	1.1	1.2	3.1	1.8	13.5-15.6
35.1-40.0	2.0	2.1	1.1	1.2	1.1	0.0	0.2	0.8	0.4	0.5	1.2	1.6	0.9	15.7-17.9
>40.0	0.7	0.7	1.1	0.5	0.3	0.0	0.1	0.4	0.1	0.2	0.6	2.1	0.4	>17.9
AVERAGE SPEED (MPH)	16.5	16.8	14.8	15.5	12.1	11.7	10.6	11.5	9.6	12.4	14.3	14.4	12.9	
AVERAGE SPEED (M/SEC)	7.4	7.5	6.6	6.9	5.4	5.2	4.7	5.1	4.3	5.6	6.4	6.4	5.8	
AVERAGE WIND POWER (WATTS/M**2)	763.9	818.1	677.1	622.3	361.0	287.0	205.7	353.8	257.3	355.2	490.4	716.9	453.6	
PERCENT DATA RECOVERY	38.6	40.8	38.0	16.3	52.6	39.2	34.3	48.1	78.2	55.5	11.3	22.6	39.5	

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
NUMBER OF OBSERVATIONS = 16048
PERCENTAGE DATA RECOVERY = 39.5

SOURCE: GEORESEARCH, INC.

Table IV - 141

Percentage Frequency Summary for Wind Speed

ROSEBUD COUNTY - COLSTRIP BN (WINTER)

01/01/75 - 08/22/79

			WIND SPEED (MPH)															
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)																
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	0.0	2.8	4.9	6.3	8.4	7.0	11.2	7.7	9.8	10.5	16.8	9.8	0.7	2.8	1.4	16.5	7.4
	2	0.0	0.7	2.1	8.3	6.2	6.2	6.2	7.6	14.5	13.1	4.1	17.9	7.6	2.8	0.7	2.1	16.2	7.2
	3	0.0	0.0	2.8	8.3	2.8	7.6	7.6	11.1	11.8	9.0	11.8	16.7	6.9	2.1	1.4	0.0	15.6	7.0
	4	0.0	0.0	4.2	4.2	7.6	4.9	15.3	7.6	8.3	9.0	6.3	18.8	9.7	3.5	0.7	0.0	15.9	7.1
	5	0.0	0.0	4.9	3.5	6.3	8.4	7.7	8.4	10.5	9.1	8.4	21.7	9.1	1.4	0.7	0.0	15.9	7.1
	6	0.0	0.7	2.1	4.3	8.6	7.1	7.1	11.4	5.7	8.6	7.9	21.4	9.3	3.6	1.4	0.7	16.8	7.5
	7	0.0	0.7	2.1	8.6	6.4	5.0	10.7	4.3	10.0	10.0	5.0	18.6	12.1	3.6	2.9	0.0	16.8	7.5
	8	0.0	0.7	4.3	5.0	10.6	7.1	6.4	5.7	11.3	7.8	5.0	14.2	12.1	6.4	3.5	0.0	16.8	7.5
H	9	0.0	2.1	4.2	7.0	5.6	8.5	9.9	8.5	7.7	7.7	4.2	14.1	16.2	2.8	1.4	0.0	16.0	7.2
	10	0.0	2.1	2.8	9.9	5.6	9.9	9.2	6.3	7.0	4.9	9.9	15.5	9.9	3.5	3.5	0.0	15.8	7.1
O	11	0.0	1.4	3.5	7.0	7.7	4.9	10.5	14.7	4.9	4.9	7.0	16.1	6.3	6.3	3.5	1.4	16.6	7.4
	12	0.0	0.7	2.8	11.9	9.1	6.3	9.8	8.4	6.3	4.2	7.7	11.2	9.8	6.3	3.5	2.1	16.5	7.4
U	13	0.0	1.4	5.6	8.3	6.9	6.3	9.7	9.7	4.2	8.3	6.3	11.8	9.0	6.3	4.2	2.1	16.6	7.4
	14	0.0	0.0	3.4	11.6	8.8	8.8	5.4	7.5	6.8	6.8	9.5	10.9	8.2	7.5	4.1	0.7	16.3	7.3
R	15	0.0	0.0	6.1	6.1	10.1	10.8	6.8	5.4	8.8	8.1	4.1	14.9	8.1	5.4	2.7	2.7	16.4	7.3
	16	0.0	0.0	5.4	7.5	3.4	9.5	8.2	7.5	10.2	10.2	6.1	10.2	12.9	4.8	1.4	2.7	16.8	7.5
	17	0.0	0.7	2.7	4.8	5.4	10.2	7.5	10.9	13.6	3.4	7.5	14.3	11.6	4.1	2.0	1.4	16.7	7.5
	18	0.0	1.3	3.4	5.4	8.7	4.0	12.8	8.1	10.7	8.7	8.1	16.1	5.4	5.4	2.0	0.0	15.8	7.1
	19	0.0	0.7	2.0	7.3	12.0	8.0	10.0	7.3	7.3	6.7	10.7	16.0	7.3	3.3	0.7	0.7	15.3	6.8
	20	0.0	0.7	5.3	4.0	8.0	11.3	8.7	6.0	10.0	8.0	6.7	18.0	8.0	4.0	0.0	1.3	15.5	6.9
	21	0.0	0.0	4.7	2.7	8.1	10.7	8.7	6.0	10.7	10.7	8.1	16.1	9.4	2.0	1.3	0.7	16.0	7.1
	22	0.0	0.7	2.7	6.8	7.4	6.8	10.8	6.8	10.8	10.1	5.4	18.2	10.8	0.7	0.7	1.4	15.7	7.0
	23	0.0	0.7	2.7	6.7	6.7	9.4	7.4	8.1	12.8	8.7	6.7	16.8	10.1	1.3	0.7	1.3	16.0	7.1
	24	0.0	0.0	2.0	5.4	9.4	10.1	3.4	8.1	8.7	14.1	9.4	16.1	6.7	4.7	1.3	0.7	16.4	7.3
ALL HOURS		0.0	0.6	3.5	6.6	7.4	7.9	8.6	8.2	9.2	8.4	7.3	15.9	9.4	3.8	2.0	1.0	16.2	7.2

SOURCE: GEORESEARCH, INC.

Table IV - 142

Percentage Frequency Summary for Wind Speed

ROSEBUD COUNTY - COLSTRIP BN (SPRING)

01/01/75 - 08/22/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (M/SEC)																	
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	1.2	5.5	7.3	7.9	10.3	13.9	12.7	10.3	6.1	6.1	11.5	3.6	1.8	1.8	0.0	13.4	6.0
	2	0.0	0.0	6.1	9.7	6.7	12.7	8.5	13.3	10.3	9.7	5.5	11.5	1.8	1.8	2.4	0.0	13.5	6.0
	3	0.0	0.6	5.5	9.1	10.3	12.7	11.5	11.5	10.3	7.9	3.6	12.7	0.6	3.0	0.0	0.6	12.7	5.7
	4	0.0	0.6	4.8	12.1	10.3	15.2	9.1	9.7	10.3	6.7	4.2	10.9	4.2	0.6	0.6	0.6	12.6	5.6
	5	0.0	0.0	6.0	12.7	12.0	12.7	8.4	9.0	7.8	7.8	4.8	12.7	3.0	1.2	1.2	0.6	12.7	5.7
	6	0.0	0.0	4.8	12.7	13.9	7.8	10.2	9.0	10.8	5.4	6.6	13.3	1.8	3.0	0.0	0.6	13.0	5.8
	7	0.0	0.0	7.3	10.9	11.5	11.5	9.7	5.5	7.3	7.3	10.9	10.3	4.8	1.8	0.0	1.2	13.4	6.0
	8	0.0	0.0	4.3	14.0	11.0	12.2	6.1	9.1	9.8	7.3	6.1	11.0	5.5	1.2	1.2	1.2	13.5	6.0
H	9	0.0	0.0	6.7	10.4	11.6	12.2	8.5	10.4	7.9	6.1	4.3	11.0	6.7	1.2	1.8	1.2	13.5	6.0
	10	0.0	0.0	3.7	9.2	12.9	13.5	11.7	9.2	7.4	4.9	7.4	10.4	5.5	1.2	1.8	1.2	13.8	6.2
O	11	0.0	0.0	4.9	9.3	9.3	14.8	9.3	9.3	9.9	6.8	6.8	10.5	5.6	3.1	0.0	0.6	13.6	6.1
	12	0.0	0.0	3.7	9.1	9.8	11.6	10.4	8.5	12.2	6.1	6.1	11.6	7.3	1.8	0.0	1.8	14.5	6.5
U	13	0.0	1.2	1.8	8.4	10.2	7.8	12.0	9.0	13.3	4.8	8.4	12.0	7.2	1.2	1.8	0.6	14.4	6.4
	14	0.0	0.0	3.0	7.8	10.8	10.2	9.0	10.2	9.6	10.8	4.2	15.7	5.4	1.8	1.2	0.0	14.3	6.4
R	15	0.0	0.0	1.8	8.5	11.5	12.1	9.7	6.7	9.7	6.7	9.7	13.9	4.8	3.0	1.8	0.0	14.5	6.5
	16	0.0	0.0	0.6	8.5	10.9	12.1	6.7	8.5	11.5	9.1	7.3	13.3	7.9	1.8	1.2	0.6	14.9	6.6
	17	0.0	0.6	1.2	7.9	8.5	17.1	8.5	8.5	5.5	13.4	6.1	13.4	4.9	2.4	1.8	0.0	14.5	6.5
	18	0.0	0.0	1.2	7.9	10.9	13.9	10.9	8.5	8.5	7.3	5.5	17.0	4.8	2.4	0.6	0.6	14.4	6.4
	19	0.0	1.2	6.0	6.0	10.2	16.9	9.6	9.6	6.6	7.8	4.8	13.3	4.8	1.8	0.6	0.6	13.3	5.9
	20	0.0	0.0	4.8	11.4	14.5	12.7	11.4	8.4	5.4	9.6	3.0	11.4	4.2	1.8	0.6	0.6	12.6	5.6
	21	0.0	0.6	4.8	11.4	12.7	12.7	8.4	10.2	10.8	5.4	4.8	9.6	4.8	1.8	1.2	0.6	12.8	5.7
	22	0.0	1.2	4.8	9.1	13.9	13.3	9.7	8.5	6.1	7.3	5.5	10.9	6.1	1.8	1.2	0.6	13.3	5.9
	23	0.0	0.0	7.3	9.1	9.8	11.6	4.9	13.4	9.1	6.7	8.5	12.2	3.7	2.4	1.2	0.0	13.4	6.0
	24	0.0	0.6	7.3	7.9	7.3	8.5	12.1	13.9	9.7	11.5	4.8	7.3	6.1	1.2	1.8	0.0	13.5	6.0
ALL HOURS		0.0	0.3	4.5	9.6	10.8	12.3	9.6	9.7	9.2	7.6	6.0	12.0	4.8	1.9	1.1	0.6	13.6	6.1

SOURCE: GEORESEARCH, INC.

Table IV - 143

Percentage Frequency Summary for Wind Speed

ROSEBUD COUNTY - COLSTRIP BN (SUMMER)

01/01/75 - 08/22/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	4.4	7.7	5.5	12.1	9.9	17.6	14.3	7.1	6.0	4.9	6.6	2.2	1.6	0.0	0.0	11.4	5.1
	2	0.5	4.4	7.7	8.2	12.6	15.3	10.9	9.3	10.9	5.5	6.6	4.9	2.2	0.5	0.5	0.0	11.0	4.9
	3	0.5	4.4	8.2	9.8	10.4	16.4	9.8	9.8	9.3	7.7	3.3	6.6	2.2	1.1	0.5	0.0	11.0	4.9
	4	0.5	4.9	6.6	9.8	13.1	13.1	10.4	13.1	9.3	6.6	3.3	7.1	2.2	0.0	0.0	0.0	10.7	4.8
	5	0.6	4.4	3.9	11.6	13.8	14.4	14.4	9.9	7.7	5.5	4.4	6.1	2.8	0.6	0.0	0.0	10.9	4.9
	6	0.6	3.3	6.6	15.5	11.6	12.7	11.0	13.3	5.5	4.4	5.0	8.8	1.7	0.0	0.0	0.0	10.5	4.7
	7	0.6	3.9	7.7	13.8	19.3	9.4	13.3	8.3	2.8	5.0	5.5	9.4	1.1	0.0	0.0	0.0	10.1	4.5
	8	0.6	5.0	10.5	11.6	11.0	12.2	12.2	9.4	7.2	3.9	7.2	8.3	0.6	0.6	0.0	0.0	10.3	4.6
H	9	1.1	3.8	8.2	15.4	12.6	9.9	9.3	7.7	8.8	6.6	4.9	8.2	2.2	0.5	0.0	0.5	10.9	4.9
	10	1.1	3.8	8.7	5.5	21.9	11.5	10.9	5.5	7.1	7.1	5.5	8.7	1.1	1.1	0.5	0.0	11.0	4.9
O	11	1.1	3.8	3.8	12.0	14.7	14.7	12.0	6.0	6.0	7.1	4.9	10.3	2.2	1.1	0.5	0.0	11.4	5.1
	12	0.5	2.7	4.4	12.1	11.5	17.0	9.9	9.9	7.1	4.9	8.2	8.8	2.2	0.0	0.0	0.5	11.4	5.1
U	13	0.0	3.9	2.2	11.6	11.6	18.2	9.9	8.8	8.3	8.3	5.5	10.5	0.6	0.0	0.0	0.6	11.6	5.2
	14	1.1	3.3	0.5	10.9	15.2	13.0	15.2	9.8	7.1	6.0	3.8	13.0	0.5	0.0	0.5	0.0	11.5	5.1
R	15	0.0	2.7	3.8	6.6	16.9	15.3	10.4	14.2	7.7	4.9	6.6	8.7	0.5	1.1	0.5	0.0	11.6	5.2
	16	0.0	4.3	2.2	11.4	12.5	10.9	8.2	16.8	10.3	8.2	3.8	9.2	0.5	1.1	0.5	0.0	11.7	5.2
	17	1.1	2.7	2.7	10.9	11.5	12.6	14.8	10.4	9.8	7.7	6.6	6.0	1.1	0.5	1.1	0.5	11.8	5.3
	18	1.6	2.2	3.8	14.1	8.7	7.6	15.2	10.9	9.8	7.6	7.1	7.1	2.2	0.5	1.1	0.5	12.1	5.4
	19	0.5	3.8	2.2	12.0	9.8	12.0	13.1	8.2	6.6	9.8	6.0	12.6	0.5	2.2	0.0	0.5	12.4	5.5
	20	0.5	2.2	4.9	7.1	13.7	15.4	9.3	9.9	9.3	10.4	4.9	7.1	3.3	0.0	1.6	0.0	12.1	5.4
	21	0.0	3.3	3.9	9.4	11.1	15.6	15.0	10.6	7.8	9.4	3.3	8.3	1.7	0.6	0.0	0.0	11.5	5.1
	22	1.1	3.3	6.1	6.1	7.7	18.2	15.5	11.0	11.6	3.9	6.6	6.1	1.7	1.1	0.0	0.0	11.4	5.1
	23	0.6	3.3	5.0	5.0	8.3	21.0	12.7	11.6	9.9	7.7	3.3	8.3	1.7	1.1	0.0	0.6	11.8	5.3
	24	1.1	3.8	7.1	5.5	9.3	15.9	14.8	11.5	7.1	8.8	4.4	4.9	3.3	1.1	1.1	0.0	11.8	5.3
ALL HOURS		0.6	3.7	5.3	10.1	12.6	13.8	12.3	10.4	8.1	6.8	5.2	8.2	1.7	0.7	0.4	0.2	11.3	5.1

SOURCE: GEORESEARCH, INC.

Table IV - 144

Percentage Frequency Summary for Wind Speed

ROSEBUD COUNTY - COLSTRIP BN (AUTUMN)

01/01/75 - 08/22/79

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (M/SEC)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.0-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	2.9	6.3	2.3	5.1	14.3	13.1	13.1	14.3	4.6	9.7	3.4	8.6	2.3	0.0	0.0	0.0	11.1	4.9
	2	2.8	6.8	3.4	7.9	11.3	15.8	14.1	7.3	5.6	7.3	5.6	9.0	2.8	0.0	0.0	0.0	11.0	4.9
	3	1.7	6.2	5.1	10.2	13.0	9.0	9.0	11.9	6.2	8.5	4.0	11.9	2.3	0.6	0.0	0.6	11.6	5.2
	4	2.9	5.7	3.4	10.9	8.6	13.7	12.0	9.1	9.1	5.1	6.3	8.6	2.9	0.0	1.1	0.6	11.6	5.2
	5	3.4	4.5	3.4	11.9	13.6	11.4	14.2	6.8	5.7	6.3	7.4	6.3	2.8	1.1	0.6	0.6	11.1	5.0
	6	3.4	4.0	5.1	9.1	12.6	16.0	9.7	9.7	4.0	8.6	6.9	5.7	3.4	0.0	0.6	1.1	11.5	5.2
	7	4.0	4.0	4.6	9.1	16.0	14.3	12.0	8.0	6.9	6.3	4.0	9.1	0.0	1.1	0.0	0.6	10.7	4.8
	8	3.4	5.7	5.7	10.8	11.4	11.9	15.3	8.5	9.1	2.3	4.0	8.0	1.7	1.1	0.6	0.6	10.8	4.8
H	9	2.3	6.8	9.6	6.8	8.5	16.4	7.3	13.0	7.3	6.2	6.2	5.1	1.7	1.7	1.1	0.0	10.9	4.9
O	10	2.8	5.6	9.0	7.3	13.6	9.6	11.9	6.8	9.0	6.2	6.8	6.2	1.7	2.3	1.1	0.0	11.1	5.0
	11	3.4	4.5	6.2	10.7	13.6	14.7	9.6	7.9	5.1	6.8	4.5	7.9	2.3	2.8	0.0	0.0	11.0	4.9
U	12	1.1	7.3	3.9	11.2	16.9	14.0	7.9	8.4	5.1	3.4	3.9	12.4	1.1	3.4	0.0	0.0	11.0	4.9
	13	1.1	6.8	6.2	11.9	13.6	11.3	10.7	7.3	6.2	3.4	4.0	11.9	2.3	2.3	1.1	0.0	11.3	5.1
R	14	1.1	8.5	4.0	13.6	10.7	12.4	6.2	9.6	6.8	4.0	6.8	10.7	2.3	2.3	1.1	0.0	11.6	5.2
	15	1.1	8.5	5.1	11.3	7.3	11.9	7.3	10.7	9.6	5.6	4.5	9.6	3.4	2.3	1.1	0.6	12.1	5.4
	16	0.6	8.5	4.5	10.2	10.2	9.7	11.9	7.4	9.1	6.8	4.0	10.2	3.4	1.1	2.3	0.0	12.2	5.4
	17	1.1	6.8	4.5	10.8	9.1	15.3	11.9	9.1	8.5	5.7	4.0	5.7	5.1	1.1	1.1	0.0	11.5	5.1
	18	2.3	5.6	5.6	13.0	13.0	10.7	11.3	9.6	9.0	5.1	3.4	7.3	2.3	1.7	0.0	0.0	10.7	4.8
	19	4.0	5.1	5.1	11.9	10.7	16.4	15.8	9.6	7.3	1.1	3.4	5.6	4.0	0.0	0.0	0.0	10.1	4.5
	20	1.1	8.4	2.2	12.9	14.6	14.6	14.0	7.3	8.4	4.5	3.4	5.6	2.2	0.6	0.0	0.0	10.1	4.5
	21	2.3	5.6	4.0	9.6	17.5	12.4	14.1	9.6	6.8	6.8	4.0	5.1	2.3	0.0	0.0	0.0	10.2	4.6
	22	2.9	4.6	5.7	9.7	12.6	13.7	15.4	7.4	9.7	5.1	5.7	6.3	1.1	0.0	0.0	0.0	10.3	4.6
	23	2.3	5.7	4.6	6.9	9.8	16.7	17.2	7.5	9.8	6.3	2.3	7.5	3.4	0.0	0.0	0.0	10.9	4.9
	24	1.7	8.0	4.6	5.7	11.5	12.1	14.4	10.9	9.2	7.5	5.2	6.3	2.9	0.0	0.0	0.0	10.9	4.9
ALL HOURS		2.3	6.2	4.9	10.0	12.2	13.2	11.9	9.1	7.4	5.8	4.7	7.9	2.5	1.1	0.5	0.2	11.0	4.9

SOURCE: GEORESEARCH, INC.

Table IV - 145

Annual Wind Rose Distribution

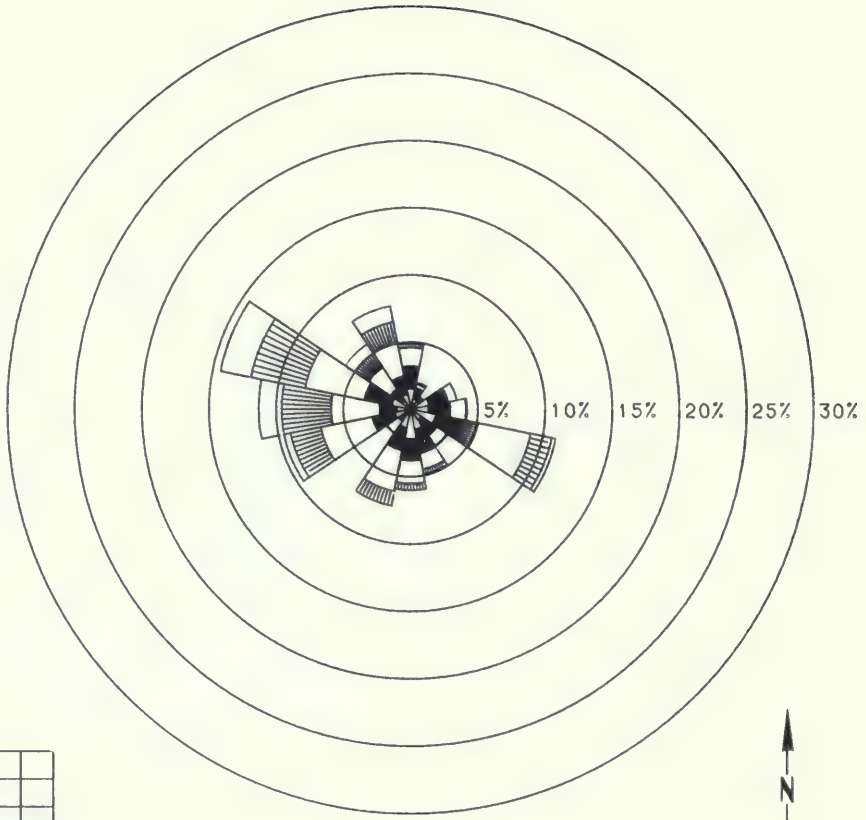
ROSEBUD COUNTY - COLSTRIP BN

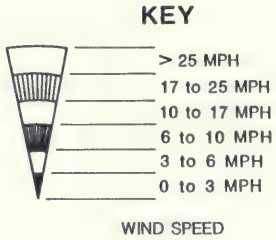
01/01/75 - 08/22/79

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.1	0.1	0.1	0.2	1.4	0.1- 0.4
1.1- 2.0	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	1.1	0.5- 0.9
2.1- 3.0	0.2	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.3	0.2	0.1	0.1	0.1	0.2	0.1	0.1	2.6	1.0- 1.3 S
3.1- 4.0	0.3	0.1	0.1	0.2	0.2	0.3	0.1	0.3	0.6	0.3	0.1	0.2	0.2	0.3	0.1	0.2	3.5	1.4- 1.8 P
S 4.1- 5.0	0.4	0.3	0.2	0.4	0.3	0.5	0.3	0.4	0.6	0.4	0.1	0.3	0.2	0.4	0.1	0.2	4.9	1.9- 2.2 E
P 5.1- 6.0	0.5	0.3	0.1	0.5	0.4	0.6	0.3	0.5	0.5	0.4	0.1	0.3	0.3	0.3	0.2	0.3	5.5	2.3- 2.7 E
E 6.1- 7.0	0.5	0.2	0.1	0.4	0.4	0.6	0.3	0.4	0.3	0.5	0.1	0.3	0.3	0.4	0.2	0.4	5.4	2.8- 3.1 D
E 7.1- 8.0	0.4	0.2	0.1	0.3	0.4	0.8	0.4	0.5	0.5	0.4	0.2	0.4	0.3	0.5	0.3	0.5	6.1	3.2- 3.6
D 8.1- 9.0	0.4	0.2	0.1	0.4	0.4	0.9	0.4	0.5	0.4	0.3	0.2	0.5	0.3	0.7	0.3	0.3	6.2	3.7- 4.0 M
9.1-10.0	0.4	0.2	0.1	0.3	0.4	0.9	0.3	0.4	0.4	0.5	0.2	0.5	0.4	0.5	0.3	0.3	5.8	4.1- 4.5 E
M 10.1-11.0	0.3	0.1	0.1	0.2	0.3	0.7	0.2	0.3	0.4	0.5	0.2	0.6	0.4	0.6	0.3	0.4	5.5	4.6- 4.9 T
I 11.1-12.0	0.3	0.1	0.0	0.2	0.2	0.7	0.1	0.2	0.4	0.4	0.2	0.7	0.5	0.5	0.3	0.4	5.2	5.0- 5.4 E
L 12.1-13.0	0.2	0.1	0.0	0.1	0.2	0.6	0.2	0.2	0.2	0.5	0.2	0.5	0.6	0.6	0.2	0.4	4.7	5.5- 5.8 R
E 13.1-14.0	0.2	0.0	0.0	0.1	0.2	0.6	0.1	0.2	0.2	0.4	0.1	0.6	0.4	0.7	0.3	0.4	4.6	5.9- 6.3 S
S 14.1-15.0	0.2	0.0	0.0	0.1	0.1	0.5	0.1	0.1	0.2	0.5	0.1	0.5	0.6	0.7	0.3	0.4	4.3	6.4- 6.7 /
/ 15.1-16.0	0.1	0.0	0.0	0.0	0.1	0.5	0.1	0.1	0.2	0.5	0.1	0.5	0.5	0.7	0.3	0.3	4.1	6.8- 7.2 S
H 16.1-17.0	0.1	0.0	0.0	0.0	0.1	0.4	0.1	0.1	0.1	0.3	0.1	0.5	0.6	0.7	0.2	0.2	3.5	7.3- 7.6 E
O 17.1-18.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.1	0.3	0.0	0.4	0.8	0.7	0.2	0.3	3.4	7.7- 8.0 C
U 18.1-19.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.3	0.0	0.4	0.5	0.6	0.2	0.2	2.7	8.1- 8.5 O
R 19.1-20.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.1	0.2	0.0	0.3	0.6	0.7	0.2	0.2	2.8	8.6- 8.9 N
20.1-25.0	0.1	0.1	0.1	0.0	0.1	0.8	0.1	0.1	0.2	0.3	0.1	1.2	1.8	2.1	0.7	0.9	8.8	9.0-11.2 D
25.1-30.0	0.0	0.1	0.1	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.4	1.0	1.3	0.4	0.6	4.5	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.7	0.2	0.3	1.8	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.1	0.2	0.9	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.5	>17.9
CALM																	0.1	CALM
TOTAL	5.2	2.2	1.2	3.5	4.1	11.0	3.5	4.7	6.2	7.3	2.3	9.6	11.2	14.4	5.6	7.7	100.0	TOTAL
AV SPD (MPH)	9.9	9.9	12.1	8.6	9.1	11.8	10.0	9.5	9.6	11.4	10.7	14.3	17.2	17.1	15.7	15.3	13.2	AV SPD (MPH)
AV SPD (M/S)	4.4	4.4	5.4	3.9	4.1	5.3	4.4	4.3	4.3	5.1	4.8	6.4	7.7	7.6	7.0	6.8	5.9	AV SPD (M/S)

SOURCE: GEORESEARCH, INC.

Figure IV - 16
Annual Wind Rose
COLSTRIP BN — ROSEBUD COUNTY
(1975 - 1978)





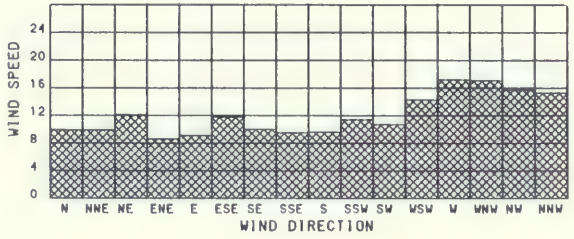


Table IV - 146

Coefficients of Weibull Distribution

ROSEBUD COUNTY - COLSTRIP BN

01/01/75 - 08/22/79

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	8.1857	2.2640
FEBRUARY	8.7885	2.0113
MARCH	7.2949	1.8616
APRIL	7.8658	1.8903
MAY	5.9276	1.9930
JUNE	5.9357	1.8730
JULY	5.1494	2.2689
AUGUST	6.4472	1.6983
SEPTEMBER	5.4611	1.1807
OCTOBER	6.2151	2.0368
NOVEMBER	6.5962	2.5135
DECEMBER	6.8713	1.4632
YEAR	6.4642	1.8210

SOURCE: GEORESEARCH, INC.

WESTERN ENERGY #12

ROSEBUD COUNTY

The Western Energy #12 air monitoring site was established by Western Energy Company to monitor particulate concentrations around their mine. The site is located approximately 1 mile south of Colstrip at 45 52 06 N and 106 38 27 W (Site No. 114 on Map II-1). Elevation at the site is 3,280 feet.

Wind data have been gathered at this site since January 1, 1981. Data through March 15, 1982, were available for analysis. The data set consists of hourly averages of wind speed and wind direction collected at an anemometer height of 10 meters above ground level. Data recovery was excellent, ranging from 77.6 percent in March to 98.6 percent in June and November. Overall data recovery was 91.5 percent.

Average annual wind speed was 7.3 miles per hour. Average monthly wind speeds varied from 5.9 miles per hour in November to 9.3 miles per hour in May. The windiest months were April through June.

Average monthly wind power ranged from 27.3 watts/m^2 in November to 79.1 watts/m^2 in May. Average annual wind power was 48.4 watts/m^2.

Table IV - 147

Monthly Wind Speed Distribution

ROSEBUD COUNTY - WESTERN ENERGY #12

01/01/81 - 03/15/82

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	SPEED (M/SEC)
CALM	0.2	0.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	CALM
0.1-1.0	2.7	5.3	3.7	1.1	1.9	0.6	0.7	0.5	0.7	1.5	1.0	2.8	2.1	0.1- 0.4
1.1-2.0	5.9	5.1	5.4	1.9	2.8	4.2	3.3	3.0	2.9	4.4	6.2	7.7	4.5	0.5- 0.9
2.1-3.0	8.5	6.6	5.5	4.7	3.2	5.4	8.5	8.4	8.5	7.0	12.4	11.1	7.5	1.0- 1.3
3.1-4.0	10.8	8.5	10.5	9.0	6.1	7.2	10.7	14.6	12.9	12.4	17.7	13.1	10.9	1.4- 1.8
4.1-5.0	15.4	10.8	10.3	8.4	8.5	11.0	12.2	18.2	15.6	12.1	15.6	11.9	12.6	1.9- 2.2
5.1-6.0	12.1	10.0	16.0	10.1	8.7	9.4	14.8	13.1	13.2	9.5	12.0	9.6	11.6	2.3- 2.7
6.1-7.0	8.8	7.5	8.9	8.0	7.0	8.5	10.4	11.8	10.3	8.8	7.5	8.5	8.7	2.8- 3.1
7.1-8.0	5.8	7.1	8.1	7.8	7.9	8.6	10.2	7.2	8.5	7.3	5.1	6.9	7.4	3.2- 3.6
8.1-9.0	4.4	6.6	6.9	6.3	7.1	5.9	6.8	6.5	4.6	5.4	3.0	3.1	5.5	3.7- 4.0
9.1-10.0	4.5	5.0	4.8	3.8	4.7	7.0	5.9	3.0	3.9	6.0	3.1	4.0	4.7	4.1- 4.5
10.1-11.0	3.2	4.6	2.9	3.6	6.7	6.5	4.5	3.0	3.5	5.2	2.7	4.0	4.1	4.6- 4.9
11.1-12.0	3.0	3.0	4.2	5.4	6.0	4.5	3.6	2.6	3.2	4.0	3.1	3.2	3.7	5.0- 5.4
12.1-13.0	2.7	3.8	4.2	6.4	5.5	3.1	2.3	2.8	3.8	4.7	2.7	2.2	3.6	5.5- 5.8
13.1-14.0	2.2	3.5	2.5	5.0	4.4	2.8	2.0	1.7	2.5	2.9	3.4	2.8	2.9	5.9- 6.3
14.1-15.0	1.2	2.8	1.3	4.1	4.5	3.4	1.0	0.8	2.0	2.7	1.4	3.5	2.3	6.4- 6.7
15.1-16.0	1.5	2.5	1.6	3.6	3.4	2.8	0.7	0.5	1.9	1.1	1.0	1.7	1.9	6.8- 7.2
16.1-17.0	1.7	1.5	1.3	3.6	3.8	1.8	0.6	0.2	1.0	1.2	0.8	0.5	1.5	7.3- 7.6
17.1-18.0	1.2	1.7	0.7	1.6	2.2	2.1	0.3	0.3	0.7	1.2	0.7	0.6	1.2	7.7- 8.0
18.1-19.0	0.8	0.9	0.7	1.9	1.6	1.4	0.3	0.2	0.1	0.8	0.7	0.3	0.8	8.1- 8.5
19.1-20.0	0.9	1.2	0.1	1.6	1.0	0.7	0.1	0.6	0.3	0.3	0.0	0.6	0.7	8.6- 8.9
20.1-25.0	2.0	1.4	0.1	1.9	2.9	2.8	0.9	0.6	0.0	1.5	0.0	1.4	1.3	9,0-11.2
25.1-30.0	0.4	0.3	0.0	0.4	0.0	0.3	0.1	0.5	0.0	0.0	0.0	0.3	0.2	11.3-13.4
30.1-35.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	6.9	7.5	6.7	9.0	9.3	8.4	6.7	6.3	6.7	7.4	5.9	6.6	7.3	
AVERAGE SPEED (M/SEC)	3.1	3.4	3.0	4.0	4.1	3.8	3.0	2.8	3.0	3.3	2.7	3.0	3.3	
AVERAGE WIND POWER (WATTS/M**2)	54.1	56.9	34.7	76.2	79.1	65.4	31.2	29.2	30.8	46.8	27.3	48.8	48.4	
PERCENT DATA RECOVERY	93.0	88.1	77.6	97.5	92.2	98.6	93.3	86.3	96.1	97.9	98.6	87.2	91.5	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 9638
PERCENTAGE DATA RECOVERY = 91.5

SOURCE: GEORESEARCH, INC.

SPEED (MPH)

SPEED (M/SEC)

BUTTE FAA AIRPORT

SILVER BOW COUNTY

The Butte Airport is located approximately 4 miles south-southeast of Butte at 45 57 00 N and 112 30 00 W (Site No. 117 on Map II-1). Elevation at the airport is 5,540 feet. Meteorological data have been collected at this site for many years by the Federal Aviation Administration.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories.

The Battelle data set for Butte consists of summaries derived from hourly observations from January 1, 1948, through December 31, 1960. The anemometer was mounted on a rooftop at a height of 18.0 meters. Due to the area's complex terrain, the site is representative only of a limited area near the airport.

Average monthly wind speed at the site ranged from 6.7 miles per hour in December and January to 9.8 miles per hour in April. Average annual wind speed was 8.1 miles per hour.

Average monthly wind power ranged from 67.0 watts/m² in August to 136.0 watts/m² in April. Average annual wind power was 90.0 watts/m².

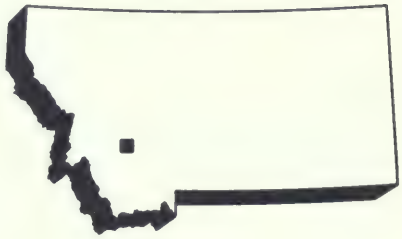


Table IV - 148

Monthly Wind Speed Distribution

SILVER BOW COUNTY - BUTTE FAA AIRPORT

01/01/48 - 12/31/60

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	20.7	19.2	16.0	10.7	9.5	9.0	11.0	12.5	13.4	15.7	20.3	24.7	15.2	CALM (<0.5)
1.1- 3.1	8.2	7.7	6.4	5.7	4.4	4.6	5.9	4.2	5.9	6.8	7.1	6.3	6.1	0.5- 1.4
3.4- 5.4	25.2	23.1	24.1	18.4	19.0	20.3	21.5	22.6	23.6	21.5	20.1	20.9	21.7	1.5- 2.4 S
S 5.6- 7.6	13.1	12.1	13.1	12.2	14.2	15.4	17.0	17.1	15.7	15.9	14.1	13.8	14.5	2.5- 3.4 P
P 7.8- 9.8	8.0	8.1	9.7	9.9	11.7	12.4	12.6	12.2	11.1	9.9	10.1	9.4	10.4	3.5- 4.4 E
E 10.1-12.1	7.1	7.8	8.1	10.6	11.0	11.2	11.3	10.6	10.1	8.9	8.8	6.8	9.4	4.5- 5.4 E
E 12.3-14.3	3.9	5.0	4.7	6.9	7.2	7.0	6.3	6.4	5.6	5.2	4.9	4.2	5.6	5.5- 6.4 D
D 14.5-16.6	3.5	4.7	4.7	6.5	6.6	6.2	4.8	4.9	4.7	4.4	4.3	4.0	4.9	6.5- 7.4
16.8-18.8	2.7	3.6	3.9	5.8	5.5	5.1	3.5	3.7	3.8	3.9	3.7	3.3	4.0	7.5- 8.4 M
M 19.0-21.0	2.3	3.1	3.1	4.5	3.6	3.5	2.4	2.6	2.7	2.8	2.3	2.0	2.9	8.5- 9.4 E
I 21.3-23.3	1.4	1.7	2.1	3.2	2.5	2.1	1.2	1.5	1.4	1.9	1.5	1.5	1.8	9.5-10.4 T
L 23.5-25.5	1.4	1.5	1.2	2.3	1.8	1.3	1.0	0.7	1.0	1.3	1.1	1.3	1.3	10.5-11.4 E
E 25.7-27.7	1.3	1.2	1.5	1.6	1.6	1.1	0.8	0.5	0.6	0.8	0.8	0.9	1.1	11.5-12.4 R
S 28.0-30.0	0.5	0.5	0.6	0.9	0.6	0.6	0.4	0.2	0.3	0.5	0.5	0.4	0.5	12.5-13.4 S
/ 30.2-32.2	0.3	0.1	0.3	0.2	0.3	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	13.5-14.4 /
H 32.4-34.4	0.2	0.2	0.2	0.3	0.2	0.2	0.1	0.0	0.1	0.2	0.3	0.1	0.2	14.5-15.4 S
O 34.7-36.7	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	16.5-17.4 C
R 39.1-41.2	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	6.7	7.4	7.8	9.8	9.4	8.9	8.1	7.8	7.6	7.6	7.2	6.7	8.1	
AVERAGE SPEED (M/SEC)	3.0	3.3	3.5	4.4	4.2	4.0	3.6	3.5	3.4	3.4	3.2	3.0	3.6	
AVERAGE WIND POWER (WATTS/M**2)	84.0	96.0	101.0	136.0	118.0	97.0	73.0	67.0	70.0	85.0	83.0	76.0	90.0	

ANEMOMETER HEIGHT = 59.0 FEET = 18.0 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

BUTTE HEBGEN PARK

SILVER BOW COUNTY

The Hebgen Park site is located in the southeastern corner of Hebgen Park in Butte at 46 00 13 N and 112 31 29 W (Site No. 118 on Map II-1). Elevation at the site is 5,520 feet. The site was established by the Montana Air Quality Bureau to measure concentrations of particulates, carbon monoxide, and nitrogen dioxide as part of the Montana Air Pollution Study.

Wind data from June 15, 1978, through December 10, 1980, were available for analysis. The data set contains hourly averages of wind speed and wind direction. The data were recorded by a data acquisition system, which scanned each measured parameter several times per minute. The wind recorder used was a Climatronics electronic anemometer and wind vane on a 10-meter tower.

Winds were monitored long enough to adequately represent the wind resource at this location. Since the site is in an urban area in complex terrain, the data are representative only of the immediate vicinity. Data recovery was fair, ranging from 35.5 percent in January to 98.7 percent in November. Overall data recovery was 75.2 percent.

Average annual wind speed at the site was 3.7 miles per hour. Average monthly wind speeds ranged from 2.8 miles per hour in November and February to 4.6 miles per hour in June. May through July were the windiest months.

Average annual wind power was 8.9 watts/m^2. Average monthly wind power values ranged from 2.7 watts/m^2 in February to 13.2 watts/m^2 in June.

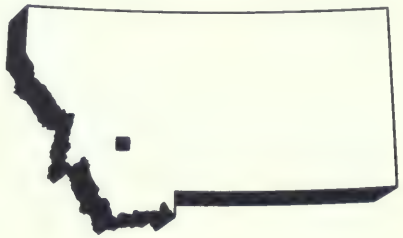


Table IV - 149

Monthly Wind Speed Distribution

SILVER BOW COUNTY - BUTTE HEBGEN PARK

06/15/78 - 12/10/80

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	2.1	0.4	2.3	1.2	1.6	0.2	0.0	0.0	0.0	0.2	1.0	2.4	0.8	CALM
0.1-1.0	19.7	2.1	8.2	8.5	2.5	2.0	1.4	0.8	2.1	8.6	14.9	14.1	6.9	0.1- 0.4
1.1-2.0	28.2	35.1	19.7	22.3	20.1	18.6	22.2	30.0	30.4	35.4	33.0	26.8	27.0	0.5- 0.9
2.1-3.0	21.2	37.2	19.5	19.2	19.5	23.0	22.8	22.5	20.0	18.9	22.3	20.0	21.5	1.0- 1.3
3.1-4.0	1.1	3.5	8.4	7.7	7.3	7.2	8.5	7.9	8.8	5.2	5.7	6.6	6.8	1.4- 1.8
4.1-5.0	10.8	10.2	11.8	10.3	11.8	12.6	12.8	12.6	8.1	8.5	7.6	7.8	10.2	1.9- 2.2
5.1-6.0	0.6	1.2	4.8	4.8	7.3	6.4	4.2	5.6	5.0	4.3	2.8	2.9	4.4	2.3- 2.7
6.1-7.0	5.5	7.9	7.9	5.9	7.4	7.4	10.3	6.7	6.7	5.1	3.8	5.8	6.6	2.8- 3.1
7.1-8.0	0.6	0.4	3.6	3.8	4.8	3.8	2.9	3.2	4.3	3.1	2.7	1.7	3.1	3.2- 3.6
8.1-9.0	4.5	1.7	7.0	6.6	6.3	6.0	7.3	4.9	6.2	3.8	2.8	4.1	5.1	3.7- 4.0
9.1-10.0	0.2	0.2	0.3	1.4	3.2	2.0	1.5	1.2	1.7	0.8	0.3	1.3	1.3	4.1- 4.5
10.1-11.0	3.0	0.2	3.8	3.9	3.0	4.2	3.9	2.5	3.7	2.2	1.1	2.7	2.9	4.6- 4.9
11.1-12.0	0.0	0.0	0.4	1.3	2.0	1.7	0.4	0.7	1.2	0.7	0.2	0.7	0.8	5.0- 5.4
12.1-13.0	1.3	0.0	1.9	1.4	1.4	2.4	1.4	0.8	1.2	1.4	0.7	1.2	1.3	5.5- 5.8
13.1-14.0	0.0	0.0	0.0	0.4	0.8	1.2	0.2	0.1	0.3	0.4	0.3	0.2	0.4	5.9- 6.3
14.1-15.0	1.1	0.0	0.4	1.2	0.6	0.7	0.3	0.3	0.1	0.7	0.2	0.8	0.5	6.4- 6.7
15.1-16.0	0.0	0.0	0.0	0.1	0.2	0.4	0.0	0.1	0.2	0.1	0.4	0.2	0.2	6.8- 7.2
16.1-17.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.2	0.2	0.1	0.2	0.1	7.3- 7.6
17.1-18.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.2	0.0	7.7- 8.0
18.1-19.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.2	0.0	8.1- 8.5
19.1-20.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	8.6- 8.9
20.1-25.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0-11.2
25.1-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3-13.4
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	3.0	2.8	3.9	4.0	4.4	4.6	4.2	3.7	3.9	3.4	2.8	3.3	3.7	
AVERAGE SPEED (M/SEC)	1.3	1.2	1.8	1.8	1.9	2.1	1.9	1.6	1.7	1.5	1.2	1.5	1.7	
AVERAGE WIND POWER (WATTS/M**2)	7.4	2.7	9.3	10.8	11.7	13.2	9.1	6.9	9.0	8.5	5.4	9.5	8.9	
PERCENT DATA RECOVERY	35.5	37.9	51.8	77.2	88.7	87.5	86.3	66.7	59.3	94.0	98.7	95.1	75.2	

SPEED (MPH)

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 16435
PERCENTAGE DATA RECOVERY = 75.2

SOURCE: GEORESEARCH, INC.

CHOTEAU
TETON COUNTY

The Choteau site is located about 12 miles southwest of Choteau at 47 44 36 N and 112 26 05 W (Site No. 125 Map II-1). Elevation at the site is 4,320 feet. This site was established by the Bureau of Reclamation as part of its Northern Great Plains Wind Energy Study. The Department of Natural Resources and Conservation assumed responsibility for monitoring winds at the site in October 1982.

Collection of wind data began on June 4, 1981 and continued until August 16, 1983. Data from the wind sensors were continuously recorded on cassette tape. These tapes were further processed by computer to yield hourly averages of wind speed, wind direction, the average cube of the hourly speed, and standard deviation of the hourly speed. In addition, the maximum and minimum instantaneous values of wind speed during each hour were recorded. Anemometer height was 10 meters.

Data recovery was good to excellent during most months; it ranged from 30.4 percent in January to 100.0 percent in May. Overall data recovery was 84.5 percent. When the site was decommissioned, the crossarm was found to be loose and probably wobbled ten to twenty degrees. This would have affected the data somewhat, particularly the data on wind direction.

Winds were monitored long enough to adequately represent the wind resource in this area during most parts of the year. The site was located towards the bottom of the Deep Creek drainage and so was somewhat protected from the winds. The speeds recorded probably are lower than what would be found on the ridges to the north and south.

Average monthly wind speeds ranged from 7.3 miles per hour in January (probably not a representative value because of the low rate of data recovery for that month) to 12.2 miles per hour in December. Average annual wind speed was 10.1 miles per hour.

Average monthly wind power varied from 48.6 watts/m^2 in August to 237.7 watts/m^2 in December. Average annual wind power was 116.0 watts/m^2.

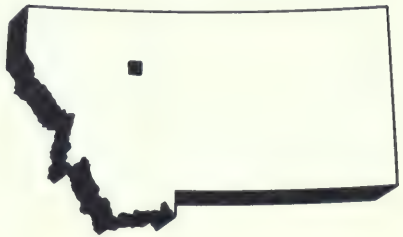


Table IV - 150

Monthly Wind Speed Distribution

TETON COUNTY - CHOTEAU

06/04/81 - 08/16/83

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.2	1.9	0.3	0.3
0.1-1.0	2.0	1.3	0.8	0.2	0.1	0.4	0.1	0.1	0.2	0.6	1.8	0.8	0.6
1.1-2.0	10.6	4.9	3.0	1.5	1.7	2.4	1.6	1.6	1.6	1.1	2.4	3.3	2.4
2.1-3.0	10.2	5.1	5.3	3.2	2.2	2.7	3.0	4.0	2.6	2.0	3.1	4.7	3.6
3.1-4.0	10.2	6.5	8.0	7.1	4.5	8.0	7.2	6.6	6.4	6.0	4.7	7.6	6.7
4.1-5.0	7.1	4.7	6.7	7.7	5.1	7.2	7.4	8.9	7.4	5.2	5.4	5.9	6.7
5.1-6.0	9.9	6.8	9.8	10.1	9.6	11.0	12.8	13.2	10.5	7.4	7.7	5.7	9.8
6.1-7.0	7.3	5.3	7.1	8.5	7.9	9.0	10.5	10.4	8.3	8.0	3.8	3.8	7.7
7.1-8.0	7.5	5.6	7.3	9.6	9.7	9.9	11.1	12.8	9.4	7.4	7.3	5.3	8.9
8.1-9.0	6.6	5.6	4.9	7.2	6.4	7.6	7.5	8.8	7.5	7.4	6.3	3.9	6.8
9.1-10.0	4.4	4.9	6.9	7.4	7.1	6.9	8.5	9.6	8.1	6.9	6.7	5.9	7.2
10.1-11.0	4.4	4.9	3.8	4.5	4.8	4.2	4.4	5.3	5.6	5.2	6.0	4.1	4.8
11.1-12.0	5.5	5.9	5.0	4.2	5.6	5.8	5.2	4.6	6.5	6.6	6.4	5.2	5.5
12.1-13.0	2.2	2.9	2.9	3.0	4.9	4.3	3.3	2.9	3.7	5.0	4.9	4.0	3.8
13.1-14.0	2.2	4.5	3.1	3.6	5.1	3.6	3.4	2.3	4.1	4.7	5.7	4.5	3.9
14.1-15.0	2.0	3.0	3.4	2.7	2.6	2.3	2.2	1.8	2.4	4.3	3.1	3.5	2.7
15.1-16.0	2.0	2.6	3.4	3.2	2.3	1.9	1.7	1.3	2.8	4.4	3.2	3.9	2.6
16.1-17.0	1.1	3.6	3.2	2.9	2.6	3.1	2.4	1.2	2.4	2.9	3.9	4.5	2.8
17.1-18.0	0.4	2.9	2.0	2.1	2.2	1.6	1.3	0.9	1.5	3.1	2.7	2.9	2.0
18.1-19.0	0.2	2.9	1.8	1.7	2.7	1.0	1.6	1.0	1.9	2.3	2.8	2.2	1.9
19.1-20.0	0.9	1.6	1.8	1.2	2.0	1.0	1.0	0.5	1.3	1.2	2.4	2.0	1.4
20.1-25.0	1.1	8.4	6.0	6.3	6.6	4.0	3.1	1.9	3.6	5.7	5.7	7.8	5.0
25.1-30.0	1.3	3.3	2.9	1.3	2.8	1.8	0.6	0.3	1.2	1.1	1.5	3.6	1.8
30.1-35.0	0.2	1.3	0.7	0.3	1.2	0.3	0.1	0.1	0.5	0.8	0.4	2.1	0.7
35.1-40.0	0.2	0.8	0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.9	0.2
>40.0	0.2	0.8	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	1.2	0.2
AVERAGE SPEED (MPH)	7.3	11.6	10.2	10.1	11.1	9.5	9.0	8.3	9.7	11.0	10.7	12.2	10.1
AVERAGE SPEED (M/SEC)	3.3	5.2	4.6	4.5	5.0	4.2	4.0	3.7	4.3	4.9	4.8	5.5	4.5
AVERAGE WIND POWER (WATTS/M**2)	66.6	206.5	124.3	114.6	135.1	85.8	65.0	48.6	85.5	129.5	119.6	237.7	116.0
PERCENT DATA RECOVERY	30.4	85.7	71.0	80.0	100.0	87.3	83.2	99.5	99.4	77.2	97.1	99.6	84.5

SPEED (MPH)	DIRECTION
CALM	CALM
0.1- 0.4	
0.5- 0.9	S
1.0- 1.3	P
1.4- 1.8	E
1.9- 2.2	E
2.3- 2.7	D
2.8- 3.1	
3.2- 3.6	M
3.7- 4.0	E
4.1- 4.5	T
4.6- 4.9	E
5.0- 5.4	R
5.5- 5.8	S
5.9- 6.3	/
6.4- 6.7	S
6.8- 7.2	E
7.3- 7.6	C
7.7- 8.0	O
8.1- 8.5	N
8.6- 8.9	D
9.0-11.2	
11.3-13.4	
13.5-15.6	
15.7-17.9	
>17.9	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 16303
PERCENTAGE DATA RECOVERY = 84.5

SOURCE: GEORESEARCH, INC.

FORT PECK
VALLEY COUNTY

The Fort Peck site was located in Valley County approximately 3 miles west of Fort Peck at 47 59 48 N and 106 29 59 W (Site No. 129 on Map II-1). Elevation at the site was 2,329 feet. The site was established by the Montana Air Quality Bureau to measure background levels of particulates in the area.

Wind data were collected at the site from May 7, 1977, through July 19, 1979. The data set consists of hourly averages of wind speed and wind direction manually reduced from stripchart records. Wind monitoring equipment included a Meteorology Research, Inc., mechanical recording anemometer and wind vane. Anemometer height was 4 meters.

Winds were monitored long enough to give an indication of the wind resource at this location. Data recovery, however, was poor during all months, ranging from 10.1 percent in April to 37.0 percent in June. Overall data recovery was 25.9 percent.

Average monthly wind speeds ranged from 8.4 miles per hour in July to 14.6 miles per hour in February. Average annual wind speed was 10.6 miles per hour.

Monthly averages of wind power ranged from 105.3 watts/m² in July to 449.2 watts/m² in February. Average annual wind power was 219.9 watts/m².

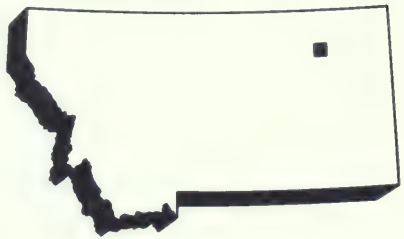


Table IV - 151

Monthly Wind Speed Distribution

VALLEY COUNTY - FORT PECK

05/07/77 - 07/19/79

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1- 0.4
1.1-2.0	0.5	1.0	1.0	0.0	0.6	0.4	1.2	0.0	0.0	0.4	0.0	0.0	0.4	0.5- 0.9
2.1-3.0	2.8	2.5	4.0	1.4	2.6	3.0	1.2	1.1	2.3	2.1	0.0	0.4	2.2	1.0- 1.3
3.1-4.0	2.8	2.5	6.5	4.1	5.0	4.8	5.6	0.8	4.9	1.7	1.1	2.8	3.8	1.4- 1.8
4.1-5.0	5.0	3.0	8.8	6.9	6.9	5.8	7.6	7.5	7.7	5.4	2.3	0.4	5.7	1.9- 2.2
5.1-6.0	8.3	4.7	7.1	4.8	7.7	10.6	12.0	7.7	8.4	4.6	5.7	2.5	7.5	2.3- 2.7
6.1-7.0	7.1	3.0	9.6	4.1	12.7	10.5	13.5	12.5	13.1	4.6	8.0	2.5	9.2	2.8- 3.1
7.1-8.0	9.0	3.5	9.0	6.2	9.8	8.0	11.2	13.9	8.6	11.7	9.0	4.6	8.7	3.2- 3.6
8.1-9.0	9.0	4.4	8.4	6.9	6.2	8.3	7.6	13.9	8.2	16.3	8.0	5.6	8.3	3.7- 4.0
9.1-10.0	7.1	3.5	7.5	2.8	8.7	6.3	10.4	6.9	8.6	6.3	5.5	5.3	6.8	4.1- 4.5
10.1-11.0	6.6	3.0	4.4	7.6	6.1	6.0	6.4	6.1	7.2	6.7	5.7	6.0	5.9	4.6- 4.9
11.1-12.0	5.2	3.2	4.4	5.5	7.3	5.5	4.0	6.4	5.8	5.4	4.1	4.9	5.3	5.0- 5.4
12.1-13.0	5.9	4.0	3.8	5.5	4.3	6.4	4.8	5.1	4.0	3.8	4.4	4.2	4.8	5.5- 5.8
13.1-14.0	3.5	5.2	4.4	8.3	3.6	3.8	2.0	3.5	3.5	3.3	5.5	6.3	4.2	5.9- 6.3
14.1-15.0	5.0	4.0	5.2	9.7	3.0	5.0	2.0	4.0	2.6	2.9	4.4	7.4	4.3	6.4- 6.7
15.1-16.0	4.5	4.0	3.3	5.5	4.4	2.9	2.8	2.4	3.7	4.6	4.6	5.3	3.8	6.8- 7.2
16.1-17.0	3.8	3.5	5.4	3.4	3.7	3.4	2.4	1.6	0.9	3.3	6.4	9.2	3.9	7.3- 7.6
17.1-18.0	2.8	5.7	2.5	4.8	1.9	3.1	0.4	1.3	1.4	3.3	4.4	2.8	2.8	7.7- 8.0
18.1-19.0	2.1	6.7	1.9	4.1	1.0	2.3	1.2	1.3	0.9	2.1	4.6	6.7	2.6	8.1- 8.5
19.1-20.0	1.7	6.9	1.0	2.8	0.6	1.1	1.6	0.3	0.2	1.3	3.2	6.0	1.9	8.6- 8.9
20.1-25.0	5.0	22.5	1.7	4.8	3.0	2.9	2.4	2.1	5.4	10.0	8.7	12.7	6.2	9,0-11.2
25.1-30.0	2.1	3.5	0.2	0.0	0.6	0.3	0.0	1.6	2.1	0.0	1.6	4.2	1.3	11.3-13.4
30.1-35.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.4	0.4	0.2	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.1	>17.9
AVERAGE SPEED (MPH)	10.7	14.6	9.2	11.6	9.3	9.5	8.4	9.4	9.6	10.9	12.9	14.4	10.6	
AVERAGE SPEED (M/SEC)	4.8	6.5	4.1	5.2	4.2	4.2	3.7	4.2	4.3	4.9	5.8	6.4	4.7	
AVERAGE WIND POWER (WATTS/M**2)	217.5	449.2	134.0	385.1	145.3	141.8	105.3	140.2	179.8	206.3	381.8	397.4	219.9	
PERCENT DATA RECOVERY	28.4	30.1	32.2	10.1	34.6	37.0	12.9	25.2	29.8	16.1	30.2	19.1	25.9	

SPEED (MPH)

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
NUMBER OF OBSERVATIONS = 4988
PERCENTAGE DATA RECOVERY = 25.9

SOURCE: GEORESEARCH, INC.

GLASGOW AIR FORCE BASE

VALLEY COUNTY

The Glasgow Air Force Base is located approximately 20 miles north-northeast of Glasgow at 48 24 00 N and 106 31 20 W (Site No. 130 on Map II-1). Elevation at the base is 2,758 feet. Meteorological data were collected at this site for many years by the United States Air Force.

These data, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The available data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the data set was split into two parts for analysis: October 1, 1958, through June 7, 1961; and June 8, 1961, through June 30, 1968. Data from the latter period only were selected for inclusion in the *Montana Wind Energy Atlas*. The anemometer was mounted on a ground mast at a height of 4.0 meters. The site is representative of the northeastern corner of Montana.

Average annual wind speed at the base was 9.6 miles per hour. Average monthly wind speeds varied from 8.7 miles per hour in August and November to 11.9 miles per hour in May.

Average annual wind power was 109.0 watts/m^2. Average monthly wind power varied from 77.0 watts/m^2 in July to 172.0 watts/m^2 in May.

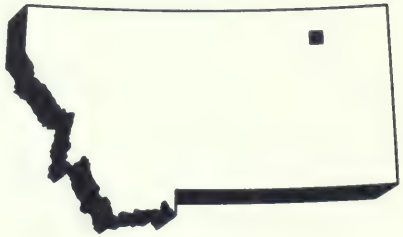


Table IV - 152

Monthly Wind Speed Distribution

VALLEY COUNTY - GLASGOW AIR FORCE BASE

06/08/61 - 06/30/68

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM (<1.1)	8.4	9.0	8.2	4.8	4.9	7.8	7.4	8.8	9.1	8.0	8.6	10.5	8.0	CALM (<0.5)	
1.1- 3.1	4.0	4.0	4.1	2.5	2.8	3.5	4.0	4.0	4.0	3.3	4.1	3.8	3.7	0.5- 1.4	
3.4- 5.4	12.2	11.9	14.0	11.1	8.9	12.1	15.7	15.0	13.5	13.6	14.9	13.2	13.0	1.5- 2.4	S
S 5.6- 7.6	15.2	16.1	17.0	15.8	12.6	16.4	16.8	17.5	15.9	17.7	19.2	16.2	16.4	2.5- 3.4	P
P 7.8- 9.8	14.7	18.6	14.9	15.1	12.8	13.9	16.9	15.6	16.7	16.6	16.5	15.9	15.7	3.5- 4.4	E
E 10.1-12.1	15.2	13.0	13.2	13.9	13.7	15.9	16.3	14.7	15.0	15.0	14.3	14.2	14.6	4.5- 5.4	E
E 12.3-14.3	10.3	8.4	9.2	10.7	12.4	10.6	8.8	9.2	8.1	9.9	8.2	9.1	9.6	5.5- 6.4	D
D 14.5-16.6	6.9	6.2	7.0	8.0	9.3	7.4	5.4	6.4	5.9	6.0	4.6	6.0	6.6	6.5- 7.4	
16.8-18.8	5.2	4.9	5.4	7.9	9.5	5.7	4.5	4.6	5.2	3.9	3.8	4.7	5.4	7.5- 8.4	M
M 19.0-21.0	3.2	2.7	3.0	3.7	4.7	2.5	2.0	1.6	2.3	2.3	2.2	2.1	2.7	8.5- 9.4	E
I 21.3-23.3	2.1	2.4	1.7	3.3	3.5	2.0	1.2	1.3	1.8	1.4	1.7	1.6	2.0	9.5-10.4	T
L 23.5-25.5	0.9	0.9	1.0	1.4	1.5	0.8	0.5	0.5	1.0	1.0	0.6	0.6	0.9	10.5-11.4	E
E 25.7-27.7	0.6	0.8	0.6	0.9	1.3	0.7	0.2	0.4	0.7	0.5	0.3	0.7	0.6	11.5-12.4	R
S 28.0-30.0	0.4	0.7	0.5	0.6	1.2	0.4	0.2	0.3	0.5	0.5	0.5	0.7	0.5	12.5-13.4	S
/ 30.2-32.2	0.2	0.2	0.0	0.1	0.3	0.1	0.0	0.0	0.1	0.2	0.2	0.4	0.2	13.5-14.4	/
H 32.4-34.4	0.1	0.1	0.0	0.1	0.3	0.0	0.1	0.0	0.1	0.2	0.0	0.2	0.1	14.5-15.4	S
O 34.7-36.7	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4	E
U 36.9-38.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	16.5-17.4	C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	17.5-18.4	O
41.4-43.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4	N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4	D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4	
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4	
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4	
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4	
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4	
AVERAGE SPEED (MPH)	9.8	9.6	9.4	11.0	11.9	9.8	8.9	8.7	9.2	9.4	8.7	9.2	9.6		
AVERAGE SPEED (M/SEC)	4.4	4.3	4.2	4.9	5.3	4.4	4.0	3.9	4.1	4.2	3.9	4.1	4.3		
AVERAGE WIND POWER (WATTS/M**2)	118.0	117.0	104.0	138.0	172.0	105.0	77.0	81.0	100.0	99.0	91.0	110.0	109.0		

ANEMOMETER HEIGHT = 13.0 FEET = 4.0 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

GLASGOW NWS AIRPORT

VALLEY COUNTY

The Glasgow airport is located approximately 1 mile north of Glasgow at 48 13 12 N and 106 37 12 W (Site No. 131 on Map II-1). Elevation at the airport is 2,280 feet.

The Glasgow area is open plains country cut by the Milk River Valley and many tributary valleys. Land in the area is used primarily for agriculture. Much of the land is privately owned; however, a substantial amount of land is owned by the state and the federal government. The Fort Peck Indian Reservation lies about 10 miles to the east. Several state and federal highways run through the area.

Electrical power is supplied by the Montana Power Company and the Valley and Northern electric cooperatives. Many power transmission lines cross the area.

The nearest other commercial airport is located at Wolf Point. The Williston Military Operations Area (MOA) is located to the northeast. The Hays and Loring MOAs are located to the southwest and northwest. These areas are subject to occasional military aviation use.

Meteorological data have been collected at this site for many years by the National Weather Service. These data, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in anemometer height, the data set has been broken into three periods for analysis: October 1, 1955, through August 5, 1962; August 6, 1962, through May 31, 1968; and June 1, 1968, through December 31, 1978. Data from the most recent period only were selected for inclusion in the *Montana Wind Energy Atlas.*

The data set for Glasgow consists of summaries of observations made every third hour. The anemometer was mounted on a ground mast at a height of 6.1 meters. The site is representative of the northeastern corner of Montana.

Average monthly wind speeds ranged from 9.8 miles per hour in November to 13.0 miles per hour in April. Average annual wind speed was 11.0 miles per hour.

Average monthly wind power ranged from 109.0 watts/m² in July to 211.0 watts/m² in April. Average annual wind power was 139.0 watts/m².

Average seasonal wind speeds were 10.4 miles per hour in autumn and winter, 10.9 miles per hour in summer, and 12.1 miles per hour in spring. The highest average wind speeds occurred in mid-afternoon during all seasons. The lowest average wind speeds occurred in early morning, except during the winter, when they occurred in mid-morning. The diurnal range of average wind speeds was greatest in summer and least in winter.

The most common wind directions were east-southeast and northwest. Winds from the south-southwest through southwest were least common. By direction, average wind speeds ranged from 7.6 miles per hour for winds from the south-southwest and southwest to 13.0 miles per hour for northwesterly winds.

Table IV - 153

Monthly Wind Speed Distribution

VALLEY COUNTY - GLASGOW NWS AIRPORT

06/01/68 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
CALM (<1.1)	6.2	5.2	3.4	2.2	2.0	2.0	2.8	1.8	3.1	3.3	5.8	5.5	3.6	CALM (<0.5)	
1.1- 3.1	0.0	0.3	0.0	0.0	0.0	0.2	0.1	0.2	0.1	0.1	0.3	0.4	0.2	0.5- 1.4	
3.4- 5.4	13.7	12.6	9.0	6.4	7.8	9.4	9.9	8.6	10.8	11.7	14.1	14.3	10.7	1.5- 2.4	S
S 5.6- 7.6	17.7	19.9	16.0	12.9	14.8	17.7	17.6	17.7	17.2	18.9	20.6	18.3	17.5	2.5- 3.4	P
P 7.8- 9.8	16.3	16.8	16.5	13.8	18.2	17.1	20.5	19.2	18.9	18.1	18.1	15.7	17.5	3.5- 4.4	E
E 10.1-12.1	13.1	13.3	16.3	15.1	16.3	15.0	16.7	16.8	15.2	14.9	12.2	12.7	14.8	4.5- 5.4	E
E 12.3-14.3	9.6	9.3	11.8	11.5	11.4	12.0	11.5	11.5	10.0	11.0	8.4	9.7	10.7	5.5- 6.4	D
D 14.5-16.6	7.5	7.0	8.3	9.8	9.1	8.7	8.1	9.1	9.0	7.3	7.3	8.4	8.3	6.5- 7.4	
16.8-18.8	5.4	4.5	6.3	9.7	6.9	7.6	5.7	6.7	6.2	5.5	5.7	6.0	6.3	7.5- 8.4	M
M 19.0-21.0	4.2	3.2	4.8	7.2	5.7	4.8	3.4	4.3	4.5	4.0	3.5	4.0	4.5	8.5- 9.4	E
I 21.3-23.3	2.4	2.8	3.0	4.6	2.9	2.3	1.6	2.2	2.3	2.5	2.0	2.5	2.6	9.5-10.4	T
L 23.5-25.5	1.9	1.7	1.9	2.9	1.5	1.9	0.6	0.8	1.0	0.9	0.8	1.3	1.4	10.5-11.4	E
E 25.7-27.7	1.0	1.6	1.0	1.7	1.4	0.8	0.5	0.7	1.0	0.8	0.4	0.9	1.0	11.5-12.4	R
S 28.0-30.0	0.4	0.6	0.7	1.1	1.0	0.3	0.5	0.3	0.4	0.4	0.2	0.2	0.5	12.5-13.4	S
/ 30.2-32.2	0.2	0.6	0.4	0.3	0.3	0.2	0.3	0.0	0.2	0.3	0.3	0.1	0.3	13.5-14.4	/
H 32.4-34.4	0.0	0.4	0.2	0.3	0.4	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.2	14.5-15.4	S
O 34.7-36.7	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	15.5-16.4	E
U 36.9-38.9	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4	C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4	O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4	N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4	D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4	
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4	
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4	
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4	
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4	
AVERAGE SPEED (MPH)	10.3	10.5	11.4	13.0	11.9	11.2	10.5	11.0	11.0	10.5	9.8	10.3	11.0		
AVERAGE SPEED (M/SEC)	4.6	4.7	5.1	5.8	5.3	5.0	4.7	4.9	4.9	4.7	4.4	4.6	4.9		
AVERAGE WIND POWER (WATTS/M**2)	139.0	152.0	161.0	211.0	164.0	131.0	109.0	116.0	129.0	126.0	114.0	126.0	139.0		

ANEMOMETER HEIGHT = 20.0 FEET = 6.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 154

Percentage Frequency Summary for Wind Speed

VALLEY COUNTY - GLASGOW NWS AIRPORT (WINTER)

06/01/68 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	6.2	0.2	12.9	19.2	18.1	12.7	10.2	7.8	4.5	2.4	2.6	1.4	1.0	0.0	0.6	0.1	10.0	4.5
	6	5.5	0.7	13.6	20.0	18.9	15.3	7.1	6.2	4.5	2.8	2.3	1.4	1.3	0.1	0.3	0.2	9.9	4.4
O	9	6.4	0.1	17.3	19.1	14.9	12.4	10.0	7.5	3.7	2.4	2.4	2.2	0.3	0.7	0.3	0.3	9.8	4.4
	12	5.1	0.3	13.8	17.8	13.3	12.5	11.6	8.2	5.4	4.1	2.8	1.7	1.9	0.8	0.1	0.4	10.8	4.8
U	15	4.8	0.1	13.0	15.0	15.3	11.6	9.2	10.4	7.7	5.4	3.0	1.5	1.8	0.8	0.7	0.0	11.3	5.1
	18	5.5	0.0	12.9	19.6	14.6	15.1	8.6	6.5	6.0	4.7	3.0	1.7	1.0	0.3	0.1	0.4	10.5	4.7
R	21	6.4	0.2	12.6	19.8	16.2	12.2	9.2	6.7	5.8	4.9	2.4	2.0	1.2	0.2	0.0	0.2	10.3	4.6
	24	5.5	0.3	12.4	18.5	18.7	12.7	10.5	7.9	5.1	3.9	2.3	1.0	0.9	0.2	0.1	0.2	10.2	4.6
ALL HOURS		5.6	0.2	13.6	18.6	16.2	13.0	9.5	7.7	5.3	3.8	2.6	1.6	1.2	0.4	0.3	0.2	10.4	4.6

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 155

Percentage Frequency Summary for Wind Speed

VALLEY COUNTY - GLASGOW NWS AIRPORT (SPRING)

06/01/68 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	2.8	0.0	10.7	17.5	18.2	17.0	12.4	7.7	5.1	3.5	2.2	1.3	1.0	0.7	0.0	0.1	10.7	4.8
	6	4.0	0.0	10.8	19.5	15.8	17.5	10.8	6.9	5.6	4.5	2.1	1.3	0.4	0.7	0.2	0.1	10.6	4.7
O	9	3.6	0.0	8.7	13.3	14.3	15.3	12.7	8.9	8.4	5.2	3.2	2.3	2.0	1.5	0.4	0.1	12.1	5.4
	12	1.4	0.0	6.3	11.3	12.5	13.9	11.2	11.4	10.2	8.9	5.1	3.2	2.0	1.3	0.6	0.7	13.7	6.1
U	15	1.4	0.0	4.9	10.6	12.9	11.3	11.3	12.0	11.7	9.9	5.3	3.1	2.8	1.0	0.5	1.2	14.3	6.4
	18	1.1	0.0	5.5	10.8	13.8	14.7	13.5	12.3	9.3	7.4	4.8	2.5	1.2	1.8	0.5	0.8	13.6	6.1
R	21	3.2	0.1	6.8	17.4	23.4	18.0	10.0	5.7	5.1	4.4	2.1	2.0	1.0	0.3	0.2	0.5	11.0	4.9
	24	2.9	0.1	8.4	16.4	18.8	19.8	10.8	7.8	5.7	3.7	3.1	1.1	0.6	0.1	0.2	0.4	11.0	4.9
ALL HOURS		2.5	0.0	7.7	14.6	16.2	15.9	11.6	9.1	7.6	5.9	3.5	2.1	1.4	0.9	0.3	0.5	12.1	5.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 156

Percentage Frequency Summary for Wind Speed

VALLEY COUNTY - GLASGOW NWS AIRPORT (SUMMER)

06/01/68 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV	AV
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	SPEED (MPH)	SPEED (M/SEC)
H	3	4.4	0.1	12.2	22.1	21.5	17.5	9.3	4.9	4.5	1.8	1.3	0.1	0.3	0.0	0.0	0.0	9.2	4.1
	6	3.7	0.3	13.2	25.6	20.8	16.0	9.4	5.1	2.6	1.5	0.6	0.5	0.5	0.1	0.0	0.0	8.9	4.0
O	9	2.2	0.2	10.9	16.1	18.4	14.4	13.2	9.9	7.2	4.2	1.5	0.7	0.8	0.3	0.1	0.0	10.9	4.9
	12	0.9	0.0	7.3	14.5	14.7	15.1	13.8	12.8	9.4	5.5	2.4	1.7	0.6	0.9	0.1	0.2	12.2	5.5
U	15	1.1	0.1	5.5	10.0	13.3	15.0	15.9	11.2	11.1	7.8	4.3	2.0	1.6	0.7	0.4	0.1	13.3	6.0
	18	0.9	0.2	4.4	11.4	15.3	16.5	14.1	13.8	9.1	6.7	2.9	2.6	1.1	0.4	0.3	0.2	12.9	5.8
R	21	2.3	0.4	10.9	21.9	25.4	15.0	7.4	6.0	4.4	3.5	1.1	1.0	0.5	0.0	0.3	0.1	9.8	4.4
	24	2.1	0.1	10.0	19.7	22.2	19.7	10.2	5.5	4.9	2.4	2.1	0.3	0.1	0.5	0.2	0.0	10.1	4.5
ALL HOURS		2.2	0.2	9.3	17.7	19.0	16.2	11.7	8.6	6.7	4.2	2.0	1.1	0.7	0.4	0.2	0.1	10.9	4.9

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 157

Percentage Frequency Summary for Wind Speed

VALLEY COUNTY - GLASGOW NWS AIRPORT (AUTUMN)

06/01/68 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
								WIND SPEED (M/SEC)										AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	5.9	0.2	14.2	20.5	21.2	13.1	9.4	7.1	4.5	1.3	1.3	0.4	0.5	0.2	0.2	0.1	9.3	4.1
	6	4.8	0.2	15.4	21.7	21.0	14.5	7.4	6.6	3.9	2.5	1.5	0.3	0.2	0.0	0.0	0.1	9.1	4.1
O	9	5.1	0.4	15.0	21.2	15.0	13.3	8.5	8.0	5.9	3.4	2.0	1.2	0.7	0.1	0.3	0.0	9.9	4.4
	12	2.4	0.0	10.2	17.9	15.5	11.1	10.9	9.9	7.8	6.7	3.5	1.2	1.3	0.9	0.2	0.6	11.9	5.3
U	15	1.8	0.0	8.3	11.5	12.1	12.9	13.0	12.8	10.3	7.5	4.3	1.6	1.6	0.9	0.7	0.8	13.1	5.9
	18	2.9	0.2	9.9	16.0	21.0	15.1	10.8	7.2	5.7	5.4	2.6	1.6	0.6	0.7	0.2	0.2	11.0	4.9
R	21	3.5	0.2	12.6	21.3	21.3	17.2	9.2	5.9	3.9	1.9	1.7	0.6	0.4	0.1	0.1	0.2	9.5	4.3
	24	6.1	0.1	12.1	21.3	19.7	15.8	9.3	5.6	4.2	3.2	1.6	0.3	0.5	0.0	0.2	0.1	9.4	4.2
ALL HOURS		4.1	0.2	12.2	18.9	18.4	14.1	9.8	7.9	5.8	4.0	2.3	0.9	0.7	0.3	0.3	0.2	10.4	4.7

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 158

Annual Wind Rose Distribution

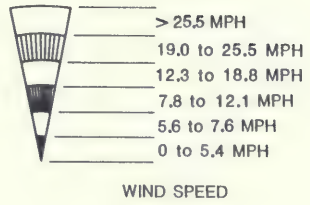
VALLEY COUNTY - GLASGOW NWS AIRPORT

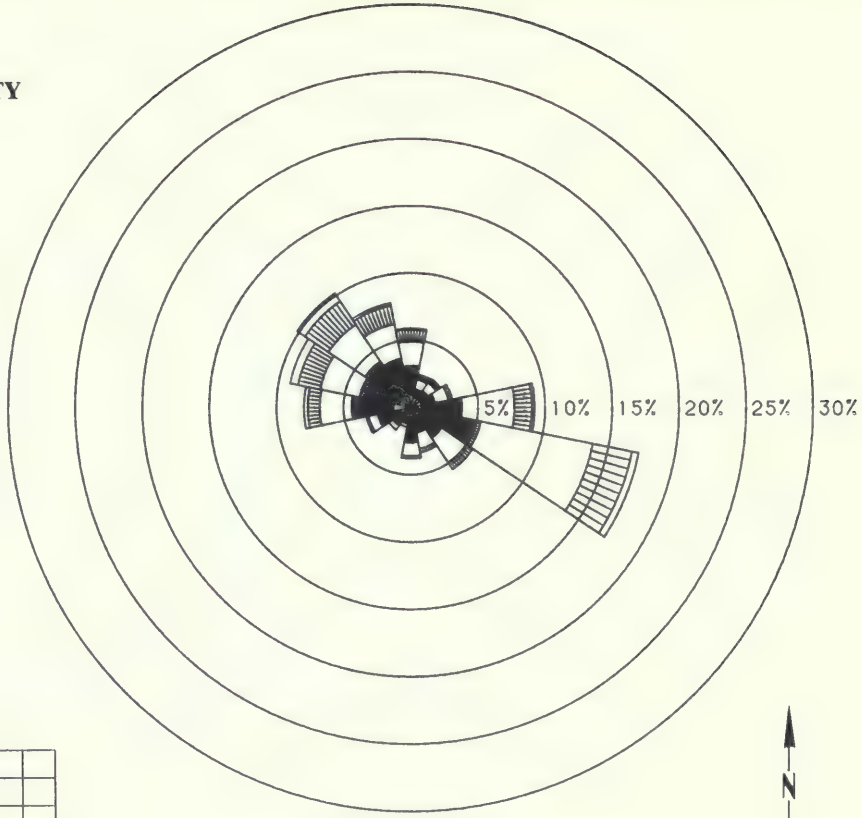
06/01/68 - 12/31/78

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4
3.4- 5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5- 2.4
5.6- 7.6	0.9	0.4	0.4	0.4	0.5	0.6	0.5	0.5	0.7	0.4	0.5	0.8	1.3	0.9	1.0	0.9	10.7	2.5- 3.4
7.8- 9.8	1.3	0.6	0.5	0.6	1.2	1.6	0.9	0.8	1.2	0.5	0.7	1.1	1.8	1.5	1.5	1.5	17.3	3.5- 4.4
10.1-12.1	0.9	0.4	0.6	0.8	2.1	3.1	1.3	0.6	0.7	0.3	0.4	0.6	1.3	1.5	1.6	1.3	17.5	4.5- 5.4
12.3-14.3	0.8	0.4	0.4	0.5	2.1	3.7	1.0	0.5	0.4	0.2	0.2	0.3	1.0	1.1	1.3	1.1	15.0	5.5- 6.4
14.5-16.6	0.5	0.2	0.2	0.3	1.1	2.8	0.7	0.4	0.4	0.1	0.1	0.2	0.7	1.0	1.0	0.8	10.5	6.5- 7.4
16.8-18.8	0.5	0.1	0.1	0.2	0.7	2.0	0.5	0.3	0.2	0.0	0.1	0.2	0.7	0.9	1.0	0.7	8.2	7.5- 8.4
19.0-21.0	0.4	0.2	0.2	0.2	0.6	1.5	0.3	0.2	0.1	0.0	0.0	0.1	0.4	0.7	0.9	0.6	6.4	8.5- 9.4
21.3-23.3	0.3	0.1	0.1	0.1	0.4	1.0	0.2	0.1	0.1	0.0	0.0	0.1	0.3	0.6	0.7	0.5	4.6	9.5-10.4
23.5-25.5	0.2	0.1	0.1	0.0	0.3	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.5	0.3	2.7	10.5-11.4
25.7-27.7	0.1	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.1	1.2	11.5-12.4
28.0-30.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.9	12.5-13.4
30.2-32.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.3	13.5-14.4
32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	14.5-15.4
34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
CALM																	3.6	CALM
TOTAL	6.0	2.6	2.7	3.3	9.3	17.4	5.4	3.4	3.9	1.6	2.1	3.4	7.9	9.2	10.2	8.0	100.0	TOTAL
AV SPD (MPH)	11.0	10.5	10.7	10.3	11.9	12.8	10.5	9.8	8.7	7.6	7.6	8.5	10.5	12.5	13.0	11.6	10.5	AV SPD (MPH)
AV SPD (M/S)	4.9	4.7	4.8	4.6	5.3	5.7	4.7	4.4	3.9	3.4	3.4	3.8	4.7	5.6	5.8	5.2	4.7	AV SPD (M/S)

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Figure IV - 17
Annual Wind Rose
GLASGOW NWS AIRPORT — VALLEY COUNTY
(1968 - 1978)





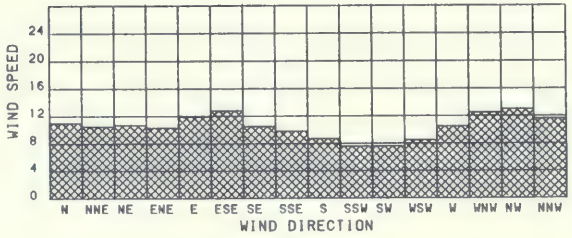


Table IV - 159

Coefficients of Weibull Distribution

VALLEY COUNTY - GLASGOW NWS AIRPORT

06/01/68 - 12/31/78

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	5.6660	1.9680
FEBRUARY	6.6380	2.6350
MARCH	6.2470	2.1430
APRIL	6.9250	2.3220
MAY	6.4370	2.2040
JUNE	6.6400	3.0260
JULY	6.5940	3.1830
AUGUST	6.3260	3.2680
SEPTEMBER	6.6630	3.1570
OCTOBER	6.7230	3.0130
NOVEMBER	6.3180	2.6950
DECEMBER	6.1650	2.8210
YEAR	6.7430	2.8560

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

JUDITH GAP
WHEATLAND COUNTY

The Judith Gap site is located about 6 miles south of the town of Judith Gap at 46 36 57 N and 109 46 11 W (Site No. 134 on Map II-1). Elevation at the site is about 4,600 feet. The site was established by the Bureau of Reclamation as part of its Northern Great Plains Wind Energy Study.

The site sits on a gently sloping plain to the south of Judith Gap. The Musselshell River flows to the south. To the northwest are the Little Belt Mountains, with summits to about 7,000 feet. The Snowy Mountains, with summits to about 8,600 feet, rise to the northeast. Between these ranges is the Judith Gap. To the southwest, the Crazy Mountains rise to over 11,000 feet.

Most of the land in the area is privately owned and used for agriculture, although a few scattered sections are owned by the state. Land in the mountains is controlled by the U.S. Forest Service.

Electrical power in the area is provided by the Montana Power Company and the Fergus Electric Cooperative. A 230-kV power transmission line runs near the site and many smaller transmission lines cross the area. The nearest commercial airport is at Lewistown. The area is in the aircraft corridors from Billings to Helena and Billings to Great Falls.

Collection of wind data at the site began on August 1, 1981. The site was closed in 1985; data are available through July 31. The data set consists of hourly averages of wind speed, wind direction, temperature, pressure, and relative humidity. Data were collected by an automatic system that transmitted information by satellite to Denver for further processing. Anemometer height was 7 meters. (It is erroneously listed in several publications as being at a height of 10 meters.)

Overall data recovery at the site was excellent; however, due to technical problems, the Bureau of Reclamation was unable to provide DNRC with copies of the data from six months. The resulting data recovery rates ranged from 47.5 percent in January to 97.9 percent in February. Overall data recovery was 81.9 percent. Data from this site should adequately represent the area in the Judith Gap.

Average annual wind speed at the site was 13.0 miles per hour. Average monthly wind speeds varied from 10.7 miles per hour in August to 15.6 miles per hour in January.

Average annual wind power was 239.2 watts/m^2. Average monthly wind power ranged from 127.4 watts/m^2 in August to 471.7 watts/m^2 in January.

Average seasonal wind speeds were 11.3 miles per hour in summer, 12.4 miles per hour in autumn, 13.5 miles per hour in spring, and 14.9 miles per hour in winter. During the summer, the highest average wind speeds occurred in late afternoon. In all other seasons, the highest average wind speeds occurred in early afternoon. The lowest average wind speeds generally occurred between 2200 MST and 0500 MST in the winter, 0300 MST in the spring, 0800 MST in the summer, and 0600 MST in the autumn. The diurnal range of average wind speeds was least in winter.

The most common wind directions were north-northwest through north and west-southwest through west-northwest. Winds from the northeast through east were least common. By direction, average speeds ranged from 5.0 miles per hour for winds from the east-northeast to 17.8 miles per hour for winds from the west.

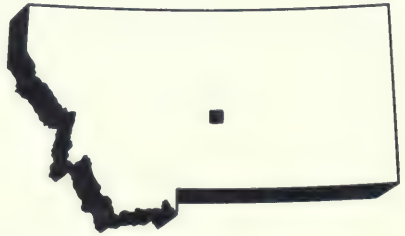


Table IV - 160

Monthly Wind Speed Distribution

WHEATLAND COUNTY - JUDITH GAP

08/06/81 - 07/31/85

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CALM
0.1-1.0	0.6	0.6	1.7	0.8	0.6	0.9	0.7	0.8	0.4	1.1	1.5	0.8	0.9	0.1- 0.4
1.1-2.0	1.8	1.9	2.4	2.2	2.1	2.2	2.5	1.8	2.4	2.8	2.7	2.7	2.3	0.5- 0.9 S
S 2.1-3.0	3.1	2.4	3.4	3.1	2.5	4.0	3.0	2.6	1.9	3.1	4.1	3.1	3.0	1.0- 1.3 P
P 3.1-4.0	4.5	4.0	5.2	5.5	4.1	5.9	6.0	7.1	5.3	6.0	6.1	5.3	5.4	1.4- 1.8 E
E 4.1-5.0	4.2	3.8	4.1	4.9	4.0	5.6	5.7	5.4	4.6	4.4	4.4	4.8	4.7	1.9- 2.2 E
E 5.1-6.0	5.9	4.6	6.2	6.0	6.1	6.7	6.9	8.3	6.0	7.1	6.3	5.8	6.3	2.3- 2.7 D
D 6.1-7.0	4.9	3.8	4.2	5.2	5.8	5.6	6.0	7.0	5.8	5.5	5.0	3.9	5.2	2.8- 3.1
7.1-8.0	5.7	4.7	4.5	6.2	5.2	6.1	7.2	7.7	6.5	6.2	4.4	3.8	5.7	3.2- 3.6 M
M 8.1-9.0	5.4	4.4	5.4	4.9	5.4	4.8	6.3	7.2	5.8	5.8	4.2	3.1	5.2	3.7- 4.0 E
I 9.1-10.0	5.2	5.0	5.6	5.6	6.5	7.6	7.3	9.5	8.9	7.0	4.7	4.7	6.5	4.1- 4.5 T
L 10.1-11.0	3.7	4.2	3.9	4.0	4.4	5.8	4.8	5.6	5.9	4.0	4.7	3.0	4.6	4.6- 4.9 E
E 11.1-12.0	4.9	5.2	5.0	5.4	5.9	5.0	5.5	6.5	6.8	5.1	5.0	4.9	5.5	5.0- 5.4 R
S 12.1-13.0	3.0	3.2	3.9	3.2	3.5	3.4	4.0	3.7	3.7	2.6	4.2	4.2	3.6	5.5- 5.8 S
/ 13.1-14.0	2.7	4.0	4.1	3.9	4.0	4.0	3.9	4.2	3.6	3.2	5.4	4.0	4.0	5.9- 6.3 /
H 14.1-15.0	2.0	3.1	3.4	2.7	3.5	3.6	3.2	2.6	2.7	2.8	4.7	3.9	3.2	6.4- 6.7 S
O 15.1-16.0	2.0	2.8	2.5	2.3	2.3	2.9	2.5	1.9	2.2	2.4	2.9	3.3	2.5	6.8- 7.2 E
U 16.1-17.0	2.5	4.5	3.5	2.8	3.0	4.0	3.7	3.5	3.3	3.7	4.2	3.5	3.6	7.3- 7.6 C
R 17.1-18.0	2.0	3.0	2.7	2.8	2.6	2.4	3.0	1.6	2.5	1.6	2.8	3.1	2.6	7.7- 8.0 O
18.1-19.0	2.0	3.7	3.1	3.2	3.2	3.0	2.5	1.6	2.8	2.3	3.4	3.5	2.9	8.1- 8.5 N
19.1-20.0	2.3	3.1	2.3	2.4	2.2	1.8	2.9	1.7	3.3	2.2	3.1	2.9	2.5	8.6- 8.9 D
20.1-25.0	10.0	13.5	13.2	9.5	10.8	8.7	7.7	5.3	9.3	9.8	10.2	12.3	10.1	9.0-11.2
25.1-30.0	9.5	8.9	6.9	6.5	7.8	4.6	3.0	2.7	4.4	7.1	4.5	8.1	6.0	11.3-13.4
30.1-35.0	5.9	3.4	2.0	4.2	3.5	1.0	1.2	1.4	1.2	3.3	1.2	4.3	2.6	13.5-15.6
35.1-40.0	3.6	1.4	0.7	1.7	0.6	0.1	0.2	0.3	0.3	0.8	0.1	0.7	0.8	15.7-17.9
>40.0	2.4	0.8	0.1	0.9	0.1	0.0	0.3	0.0	0.3	0.0	0.0	0.4	0.4	>17.9
AVERAGE SPEED (MPH)	15.6	15.0	13.3	13.7	13.7	11.7	11.5	10.7	12.2	12.8	12.3	14.3	13.0	
AVERAGE SPEED (M/SEC)	7.0	6.7	5.9	6.1	6.1	5.2	5.1	4.8	5.5	5.7	5.5	6.4	5.8	
AVERAGE WIND POWER (WATTS/M**2)	471.7	337.4	245.9	302.0	256.4	160.2	153.2	127.4	181.4	237.3	184.3	307.4	239.2	
PERCENT DATA RECOVERY	47.5	97.9	97.0	96.2	73.0	93.2	97.8	70.8	94.6	71.1	73.5	72.3	81.9	

ANEMOMETER HEIGHT = 7 METERS = 22.5 FEET
NUMBER OF OBSERVATIONS = 28626
PERCENTAGE DATA RECOVERY = 81.9

SOURCE: GEORESEARCH, INC.

Table IV - 161

Percentage Frequency Summary for Wind Speed

WHEATLAND COUNTY - JUDITH GAP (WINTER)

08/06/81 - 07/31/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
		WIND SPEED (METERS/SECOND)																AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	4.5	8.3	9.4	11.7	9.4	10.2	7.5	6.0	5.6	4.1	12.8	4.5	4.5	1.1	0.4	13.5	6.1
	2	0.0	4.1	5.6	13.2	9.0	9.8	12.4	6.0	6.8	6.4	6.0	11.3	4.5	3.0	1.5	0.4	13.4	6.0
	3	0.0	4.9	7.9	12.8	8.7	10.9	8.3	9.1	5.3	4.2	6.8	10.9	4.2	4.9	0.4	0.8	13.2	5.9
	4	0.0	3.8	8.7	10.6	7.2	11.7	11.7	7.2	6.4	8.3	4.5	7.9	6.8	4.5	0.4	0.4	13.3	6.0
	5	0.0	3.0	9.5	7.2	9.1	15.2	9.9	8.7	3.8	5.7	6.5	9.9	4.2	4.2	2.3	0.8	13.8	6.2
	6	0.0	3.8	7.3	10.0	7.3	10.0	11.5	8.0	7.7	6.9	6.9	10.3	4.2	3.8	1.1	1.1	14.0	6.3
	7	0.0	3.4	8.8	12.3	7.7	8.8	8.0	11.1	6.9	6.9	5.0	10.0	6.1	3.1	1.5	0.4	13.6	6.1
	8	0.0	1.9	9.6	8.0	10.0	8.4	9.2	8.8	8.4	6.9	4.2	13.4	6.5	2.3	1.1	1.1	14.1	6.3
H	9	0.0	1.5	8.8	11.1	10.0	7.3	6.5	6.9	8.0	8.4	5.0	14.9	5.7	2.3	2.3	1.1	14.6	6.5
	10	0.0	3.8	11.2	9.2	8.1	5.8	5.8	10.0	5.8	5.0	5.8	17.3	5.0	5.0	1.5	0.8	14.7	6.6
O	11	0.0	3.2	6.0	12.4	6.8	6.8	6.4	6.4	7.6	7.6	8.8	13.9	6.4	4.4	2.8	0.8	15.5	6.9
	12	0.0	2.7	5.8	7.6	9.8	6.3	5.4	4.0	3.1	8.9	6.7	23.2	7.6	5.8	1.8	1.3	16.9	7.6
U	13	0.0	1.5	4.1	8.6	7.9	10.1	7.5	4.5	3.0	5.2	5.6	21.3	9.4	8.6	1.5	1.1	17.4	7.8
	14	0.0	0.4	7.1	5.2	7.9	4.5	8.2	6.0	2.6	4.5	8.6	21.3	12.0	8.2	1.9	1.5	18.3	8.2
R	15	0.0	1.5	3.7	7.1	6.7	6.4	7.1	4.5	4.5	6.7	6.7	20.6	14.2	7.1	1.1	1.9	18.2	8.1
	16	0.0	1.1	6.8	3.0	6.0	9.4	6.8	6.8	6.0	6.0	9.8	18.9	8.7	7.9	1.9	0.8	17.5	7.8
	17	0.0	1.1	5.3	7.6	7.6	9.5	9.2	5.7	5.7	7.3	7.3	17.6	8.0	5.3	2.3	0.4	16.3	7.3
	18	0.0	0.8	5.7	8.4	10.3	11.1	10.3	6.9	5.7	6.1	6.5	14.5	7.3	5.3	0.4	0.8	15.0	6.7
	19	0.4	1.9	5.8	10.8	9.6	11.5	10.4	5.4	4.6	8.8	6.9	12.7	7.7	2.7	0.4	0.4	14.1	6.3
	20	0.0	3.5	6.9	10.4	9.3	10.4	8.1	6.2	5.8	8.1	6.2	15.4	3.9	4.6	0.0	1.2	14.1	6.3
	21	0.0	3.5	7.7	12.7	5.8	9.3	10.8	9.3	6.2	5.8	3.9	12.7	6.9	4.2	0.8	0.4	14.0	6.2
	22	0.0	3.9	10.1	8.9	10.1	10.1	8.9	7.8	7.4	5.4	4.7	8.9	7.4	5.4	1.2	0.0	13.7	6.1
	23	0.0	3.1	9.4	10.2	11.4	8.2	9.0	8.2	7.5	5.5	4.3	12.2	4.3	5.5	0.8	0.4	13.7	6.1
	24	0.0	4.6	6.3	13.5	11.4	8.0	8.0	8.4	5.9	6.8	5.1	9.3	7.6	3.8	0.8	0.4	13.5	6.0
ALL HOURS		0.0	2.8	7.4	9.6	8.7	9.1	8.8	7.2	5.9	6.5	6.1	14.2	6.8	4.9	1.3	0.8	14.9	6.6

SOURCE: GEORESEARCH, INC.

Table IV - 162

Percentage Frequency Summary for Wind Speed

WHEATLAND COUNTY - JUDITH GAP (SPRING)

08/06/81 - 07/31/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0		
			WIND SPEED (METERS/SECOND)															AV SPEED (MPH)	AV SPEED (M/SEC)
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9		
	1	0.0	6.2	11.0	15.4	13.4	11.3	8.3	8.6	5.0	3.6	2.7	8.0	3.0	3.0	0.6	0.0	11.0	4.9
	2	0.0	6.2	12.8	14.5	11.9	10.7	9.8	8.6	2.4	5.6	4.5	5.9	4.5	1.8	0.9	0.0	11.0	4.9
	3	0.0	5.6	11.0	13.4	13.4	13.4	8.9	8.3	4.5	4.5	3.9	7.1	2.7	3.6	0.0	0.0	11.1	4.9
	4	0.0	3.6	7.7	15.2	12.8	12.2	11.6	8.3	5.1	5.4	4.2	6.3	4.2	3.3	0.3	0.0	11.7	5.2
	5	0.0	4.2	12.2	11.9	11.0	11.9	11.3	8.0	6.5	5.4	2.1	6.8	4.8	3.6	0.3	0.0	11.7	5.2
	6	0.0	4.8	12.5	14.0	11.0	10.1	8.1	7.8	6.0	5.4	5.1	9.0	2.7	3.0	0.6	0.0	11.6	5.2
	7	0.0	4.8	15.3	12.0	8.7	9.3	8.1	3.9	6.9	6.0	5.7	11.1	2.1	4.2	1.5	0.6	12.4	5.5
	8	0.3	4.5	12.4	11.2	10.3	6.9	5.4	3.9	5.7	6.6	6.3	16.0	3.6	4.5	1.5	0.6	13.6	6.1
H	9	0.0	2.1	8.5	12.7	8.2	9.1	5.8	4.5	5.2	7.3	9.1	15.8	4.5	4.5	2.1	0.6	14.8	6.6
	10	0.0	2.1	3.4	9.8	10.1	8.9	10.7	6.1	5.8	5.8	4.9	19.0	7.0	4.0	1.8	0.6	15.6	7.0
O	11	0.0	2.9	4.5	6.8	7.7	10.9	8.4	6.8	4.8	6.8	4.5	19.3	9.6	5.8	1.0	0.3	16.1	7.2
	12	0.0	0.4	4.1	9.5	7.9	9.1	9.1	6.6	5.0	7.4	5.8	18.6	7.9	6.6	1.2	0.8	16.5	7.4
U	13	0.0	1.2	4.2	7.4	5.9	11.0	7.1	8.9	4.5	6.5	7.4	18.7	9.2	6.5	0.6	0.9	16.7	7.5
	14	0.0	0.6	3.3	8.0	6.0	8.9	10.4	7.7	5.4	6.5	5.4	19.9	10.1	6.5	0.9	0.3	16.8	7.5
R	15	0.0	2.1	1.8	4.8	7.8	13.1	5.4	7.2	7.8	5.7	8.1	21.5	7.8	5.7	0.6	0.9	16.8	7.5
	16	0.0	0.6	3.3	5.1	10.4	9.9	6.9	8.1	5.7	7.8	6.3	22.1	8.7	4.5	0.6	0.3	16.5	7.4
	17	0.0	2.1	3.6	4.5	9.3	8.4	7.8	9.6	5.4	8.7	10.2	18.3	7.8	3.6	0.9	0.0	16.0	7.2
	18	0.0	0.9	5.4	7.5	6.9	9.3	11.7	8.7	10.2	5.7	6.6	16.2	8.1	2.4	0.6	0.0	15.0	6.7
	19	0.0	3.0	4.5	10.2	11.1	12.6	9.6	9.3	6.9	6.9	6.3	14.1	3.3	0.9	0.9	0.3	13.3	5.9
	20	0.3	2.4	4.8	11.1	15.4	13.0	13.6	9.3	6.0	5.7	4.2	8.4	3.9	1.2	0.3	0.3	12.1	5.4
	21	0.0	2.4	8.2	9.7	12.8	17.9	13.4	8.2	4.6	4.9	4.9	8.5	3.0	1.2	0.3	0.0	11.6	5.2
	22	0.0	5.5	10.4	11.9	12.5	14.6	13.4	6.4	4.9	3.0	4.9	7.9	3.7	0.6	0.3	0.0	10.9	4.9
	23	0.0	4.7	14.7	11.3	9.1	13.8	11.6	8.4	5.0	4.4	4.4	6.6	2.8	2.8	0.6	0.0	11.2	5.0
	24	0.0	4.6	13.7	12.3	12.6	9.8	11.9	9.1	4.2	4.6	4.2	4.9	4.2	3.5	0.0	0.4	11.2	5.0
ALL HOURS		0.0	3.3	8.1	10.4	10.3	11.1	9.5	7.6	5.6	5.8	5.5	12.9	5.4	3.6	0.8	0.3	13.5	6.0

SOURCE: GEORESEARCH, INC.

Table IV - 163

Percentage Frequency Summary for Wind Speed

WHEATLAND COUNTY - JUDITH GAP (SUMMER)

08/06/81 - 07/31/85

		WIND SPEED (MPH)																
		CALM	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-25.0	25.1-30.0	30.1-35.0	35.1-40.0	>40.0	
			WIND SPEED (METERS/SECOND)															
		CALM	0.1-0.9	0.9-1.8	1.8-2.7	2.7-3.6	3.6-4.5	4.5-5.4	5.4-6.3	6.3-7.2	7.2-8.0	8.1-8.9	9.0-11.2	11.2-13.4	13.5-15.6	15.7-17.9	>17.9	AV SPEED (MPH)	AV SPEED (M/SEC)
	1	0.0	5.6	11.1	18.8	15.4	14.2	10.8	6.5	4.0	3.4	2.5	4.6	2.5	0.6	0.0	0.0	9.4	4.2
	2	0.0	6.5	14.2	16.4	17.9	14.5	8.0	6.2	2.5	3.7	2.5	5.2	2.5	0.0	0.0	0.0	9.0	4.0
	3	0.3	5.6	15.2	16.4	16.1	16.7	6.2	5.6	3.7	5.0	2.5	5.6	0.6	0.6	0.0	0.0	9.0	4.0
	4	0.0	5.3	16.1	17.1	15.5	15.2	9.0	6.8	3.4	2.8	1.9	5.3	0.9	0.6	0.0	0.0	8.9	4.0
	5	0.0	6.5	16.1	19.6	16.1	13.0	7.5	6.5	1.9	3.7	3.1	3.7	1.6	0.3	0.3	0.0	8.6	3.9
	6	0.0	4.0	15.9	19.0	17.8	13.1	7.2	6.2	3.4	3.4	2.8	4.7	1.9	0.3	0.3	0.0	9.0	4.0
	7	0.0	5.3	16.3	20.9	12.5	11.3	7.2	5.0	4.1	4.4	3.8	6.9	0.6	1.3	0.6	0.0	9.5	4.2
	8	0.0	5.0	15.4	19.5	11.9	8.8	7.2	6.0	5.3	3.1	5.3	8.5	2.8	0.9	0.0	0.0	10.2	4.6
H	9	0.0	1.6	13.6	15.1	15.1	8.8	8.8	6.3	6.0	5.7	5.4	8.2	3.5	1.9	0.0	0.0	11.3	5.0
	10	0.0	1.9	9.2	12.3	14.2	13.0	6.6	6.3	6.3	8.2	4.1	11.4	4.1	2.2	0.0	0.0	12.3	5.5
O	11	0.0	1.3	5.8	11.2	13.5	15.4	8.0	6.4	5.4	7.1	7.4	12.2	4.2	2.2	0.0	0.0	13.0	5.8
	12	0.0	2.0	4.7	9.5	8.4	17.9	12.2	6.4	4.4	7.4	11.1	9.5	3.4	3.0	0.0	0.0	13.3	5.9
U	13	0.0	1.9	5.3	6.2	9.3	13.0	12.7	10.8	8.4	9.0	5.3	11.5	3.4	2.5	0.6	0.3	13.7	6.1
	14	0.0	0.9	4.0	6.5	9.6	13.3	12.7	9.3	9.6	8.0	5.9	13.0	4.0	2.8	0.0	0.3	14.1	6.3
R	15	0.0	0.9	3.1	7.1	9.9	11.5	14.9	8.4	9.0	9.0	6.8	13.6	2.5	2.8	0.3	0.3	14.2	6.3
	16	0.0	0.3	3.7	4.3	9.0	12.4	14.2	12.4	6.5	9.3	7.4	14.9	3.4	1.5	0.3	0.3	14.4	6.4
	17	0.0	0.3	1.9	6.9	8.2	12.9	14.7	10.0	8.8	9.7	6.3	13.8	6.3	0.3	0.0	0.0	14.3	6.4
	18	0.0	0.9	4.1	6.6	8.8	11.6	16.0	8.5	9.7	10.7	6.9	10.3	5.0	0.6	0.0	0.3	13.7	6.1
	19	0.0	2.2	3.4	9.1	7.8	13.8	15.4	11.3	7.2	10.0	6.9	9.4	2.8	0.6	0.0	0.0	12.8	5.7
	20	0.0	3.1	7.9	8.2	12.9	15.4	16.7	10.4	6.9	7.9	2.5	5.7	1.3	1.3	0.0	0.0	11.1	5.0
	21	0.0	2.8	7.3	14.6	13.9	21.2	10.8	9.5	4.1	5.1	2.8	4.4	2.2	1.3	0.0	0.0	10.5	4.7
	22	0.0	2.9	10.2	12.4	15.3	20.1	12.4	7.6	4.1	4.5	1.6	6.7	0.6	1.3	0.0	0.3	10.2	4.6
	23	0.0	3.5	10.0	14.5	18.4	14.5	13.2	6.8	5.2	3.9	2.3	5.2	1.3	1.0	0.0	0.3	10.1	4.5
	24	0.0	2.0	13.3	14.3	16.7	15.3	11.6	4.8	6.1	4.1	4.1	5.1	1.4	1.0	0.3	0.0	10.1	4.5
ALL HOURS		0.0	3.0	9.5	12.8	13.1	14.0	11.0	7.7	5.7	6.2	4.6	8.3	2.6	1.3	0.1	0.1	11.3	5.1

SOURCE: GEORESEARCH, INC.

Table IV - 164

Percentage Frequency Summary for Wind Speed

WHEATLAND COUNTY - JUDITH GAP (AUTUMN)

08/06/81 - 07/31/85

		WIND SPEED (MPH)																
			0.1-	2.1-	4.1-	6.1-	8.1-	10.1-	12.1-	14.1-	16.1-	18.1-	20.1-	25.1-	30.1-	35.1-		
		CALM	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	35.0	40.0	>40.0	
			WIND SPEED (METERS/SECOND)															
			0.1-	0.9-	1.8-	2.7-	3.6-	4.5-	5.4-	6.3-	7.2-	8.1-	9.0-	11.2-	13.5-	15.7-		AV	AV
		CALM	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.0	8.9	11.2	13.4	15.6	17.9	>17.9	SPEED (MPH)	SPEED (M/SEC)
	1	0.0	4.7	13.7	12.0	14.0	16.0	10.0	8.0	3.3	4.7	2.7	7.0	1.3	2.3	0.3	0.0	10.4	4.7
	2	0.0	5.0	12.3	17.3	14.3	11.7	11.0	5.3	4.3	3.7	4.7	6.3	1.7	2.0	0.3	0.0	10.2	4.6
	3	0.0	3.7	11.3	15.0	16.0	12.0	13.0	5.7	6.0	3.3	4.0	5.0	3.7	0.7	0.3	0.3	10.5	4.7
	4	0.0	2.3	12.7	13.0	17.3	14.7	9.3	8.3	4.7	4.0	4.3	5.0	2.3	2.0	0.0	0.0	10.5	4.7
	5	0.0	4.7	9.0	11.0	18.4	14.7	13.0	6.4	4.7	5.7	3.7	4.7	2.7	1.3	0.0	0.0	10.5	4.7
	6	0.0	6.0	9.7	13.1	15.4	13.8	12.4	6.7	5.0	3.4	3.0	6.7	2.3	2.0	0.0	0.3	10.5	4.7
	7	0.0	3.7	13.1	11.4	14.1	14.1	9.4	6.0	5.4	5.7	4.0	8.7	3.4	0.7	0.0	0.3	11.0	4.9
	8	0.0	4.7	11.1	14.1	10.7	11.7	7.4	8.1	5.7	5.7	5.7	11.7	1.3	1.7	0.0	0.3	11.5	5.2
H	9	0.0	4.4	12.8	11.1	10.1	9.7	7.7	7.4	6.7	6.7	6.7	10.7	3.7	2.0	0.0	0.3	12.2	5.4
	10	0.0	3.7	8.5	12.6	10.2	9.5	5.8	7.1	6.5	7.5	6.1	13.6	7.5	1.0	0.3	0.0	13.3	5.9
O	11	0.0	2.5	5.8	14.2	6.3	8.8	7.1	9.6	6.3	6.7	5.8	16.7	7.9	2.1	0.4	0.0	14.3	6.4
	12	0.0	2.0	5.5	9.5	9.5	7.0	8.5	5.0	3.5	8.5	6.0	22.5	6.5	5.5	0.5	0.0	15.7	7.0
U	13	0.0	1.7	7.3	5.7	7.7	8.0	7.3	5.3	7.0	8.0	10.0	18.7	8.3	4.3	0.7	0.0	16.0	7.1
	14	0.0	1.3	4.3	7.0	8.0	8.7	8.0	8.0	6.3	8.0	6.3	21.3	6.7	5.0	1.0	0.0	16.1	7.2
R	15	0.0	0.3	3.7	7.4	7.4	10.0	9.0	7.4	7.4	7.7	7.4	22.7	6.4	3.0	0.3	0.0	15.9	7.1
	16	0.0	0.3	4.0	8.4	5.7	10.7	10.1	6.7	8.1	9.1	8.1	18.8	6.0	3.7	0.3	0.0	15.6	7.0
	17	0.0	2.0	4.7	6.4	10.1	9.4	7.7	10.7	7.4	7.0	10.4	17.4	4.0	2.0	0.7	0.0	14.7	6.6
	18	0.0	2.7	4.4	8.7	6.4	12.8	12.4	9.1	7.4	9.7	7.7	13.8	3.4	1.7	0.0	0.0	13.6	6.1
	19	0.0	4.0	4.4	10.1	8.7	13.1	15.4	11.7	8.4	6.0	6.7	7.7	2.7	1.0	0.0	0.0	12.1	5.4
	20	0.0	3.7	6.1	8.5	12.2	20.1	14.3	6.8	6.8	6.1	6.1	6.5	2.0	0.7	0.0	0.0	11.4	5.1
	21	0.0	2.4	11.6	10.6	10.6	13.0	18.1	9.2	5.5	4.4	5.8	6.1	1.7	0.7	0.3	0.0	11.0	4.9
	22	0.0	5.5	8.9	13.4	11.6	14.7	17.1	5.1	4.5	5.1	2.7	7.2	2.4	1.0	0.7	0.0	10.7	4.8
	23	0.0	7.6	11.8	11.4	11.1	13.8	11.8	9.3	4.2	4.8	5.2	4.2	3.5	1.0	0.0	0.3	10.5	4.7
	24	0.4	7.0	11.0	10.3	13.2	17.2	9.5	7.3	3.7	4.4	3.7	8.1	1.8	2.2	0.4	0.0	10.7	4.8
ALL HOURS		0.0	3.6	8.7	10.9	11.3	12.4	10.7	7.5	5.8	6.1	5.7	11.1	3.8	2.0	0.3	0.1	12.4	5.5

SOURCE: GEORESEARCH, INC.

Table IV - 165

Annual Wind Rose Distribution

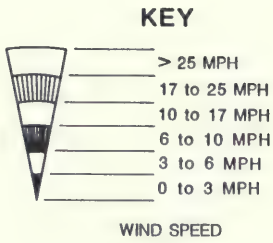
WHEATLAND COUNTY - JUDITH GAP

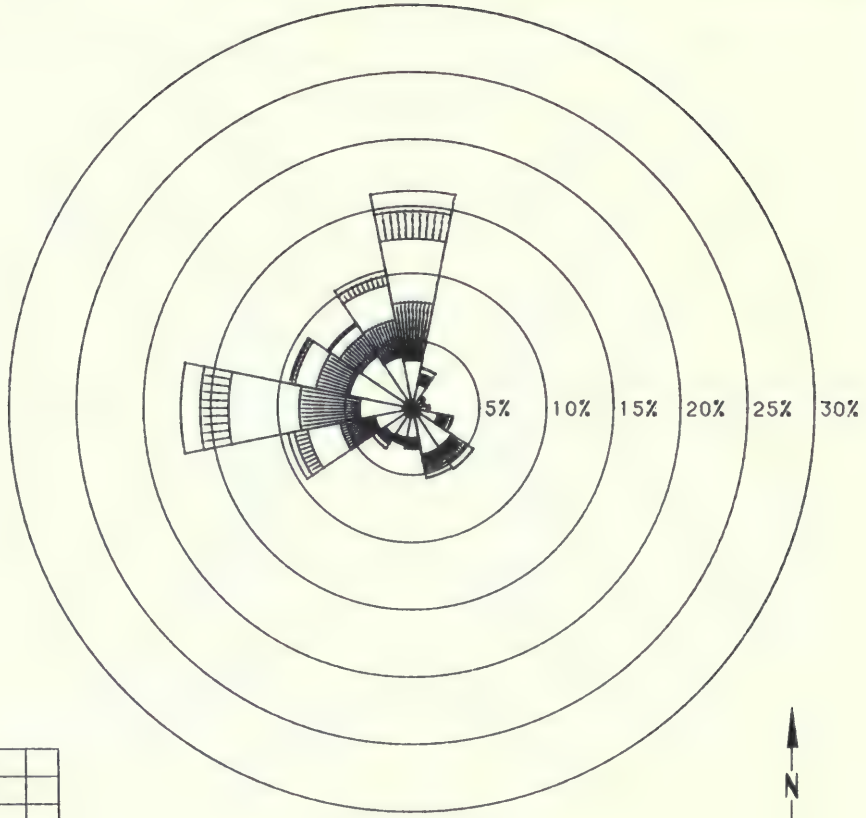
08/06/81 - 07/31/85

DIRECTION>	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION
SPEED (MPH)																		SPEED (M/SEC)
0.1- 1.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.9	0.1- 0.4
1.1- 2.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	2.3	0.5- 0.9
2.1- 3.0	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	3.0	1.0- 1.3 S
3.1- 4.0	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.5	0.4	5.4	1.4- 1.8 P
S 4.1- 5.0	0.3	0.2	0.1	0.1	0.1	0.2	0.5	0.4	0.3	0.4	0.3	0.3	0.3	0.4	0.5	0.3	4.7	1.9- 2.2 E
P 5.1- 6.0	0.4	0.2	0.1	0.1	0.1	0.2	0.5	0.6	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.5	6.3	2.3- 2.7 E
E 6.1- 7.0	0.3	0.2	0.1	0.0	0.1	0.2	0.4	0.5	0.3	0.3	0.2	0.3	0.4	0.6	0.7	0.5	5.2	2.8- 3.1 D
E 7.1- 8.0	0.5	0.2	0.1	0.0	0.1	0.2	0.5	0.5	0.3	0.2	0.2	0.3	0.5	0.7	0.7	0.6	5.7	3.2- 3.6
D 8.1- 9.0	0.5	0.2	0.0	0.0	0.0	0.2	0.4	0.5	0.2	0.1	0.2	0.3	0.5	0.7	0.8	0.5	5.2	3.7- 4.0 M
9.1-10.0	0.8	0.3	0.0	0.0	0.0	0.3	0.5	0.6	0.3	0.1	0.2	0.4	0.6	0.9	0.8	0.7	6.5	4.1- 4.5 E
M 10.1-11.0	0.6	0.2	0.0	0.0	0.0	0.1	0.4	0.3	0.1	0.1	0.1	0.3	0.5	0.7	0.5	0.5	4.6	4.6- 4.9 T
I 11.1-12.0	0.8	0.2	0.0	0.0	0.0	0.2	0.4	0.4	0.1	0.1	0.1	0.4	0.8	0.8	0.4	0.6	5.5	5.0- 5.4 E
L 12.1-13.0	0.6	0.1	0.0	0.0	0.0	0.1	0.3	0.2	0.0	0.0	0.1	0.3	0.6	0.5	0.2	0.4	3.6	5.5- 5.8 R
E 13.1-14.0	0.8	0.2	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0	0.1	0.4	0.7	0.5	0.2	0.5	4.0	5.9- 6.3 S
S 14.1-15.0	0.7	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.3	0.7	0.3	0.1	0.4	3.2	6.4- 6.7 /
/ 15.1-16.0	0.5	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.4	0.6	0.3	0.1	0.3	2.5	6.8- 7.2 S
H 16.1-17.0	0.8	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.5	0.9	0.3	0.1	0.4	3.6	7.3- 7.6 E
O 17.1-18.0	0.6	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.2	0.1	0.3	2.6	7.7- 8.0 C
U 18.1-19.0	0.8	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.4	0.8	0.2	0.1	0.3	2.9	8.1- 8.5 O
R 19.1-20.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.7	0.2	0.1	0.3	2.5	8.6- 8.9 N
20.1-25.0	2.9	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.2	1.6	3.1	0.4	0.3	1.3	10.1	9.0-11.2 D
25.1-30.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	2.1	0.2	0.1	0.8	6.0	11.3-13.4
30.1-35.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.1	0.0	0.4	2.6	13.5-15.6
35.1-40.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.1	0.9	15.7-17.9
>40.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.3	>17.9
CALM																	0.0	CALM
TOTAL	16.2	3.1	1.1	0.9	1.2	3.0	5.4	5.3	3.0	2.8	3.6	9.4	17.3	9.4	7.7	10.5	100.0	TOTAL
AV SPEED (MPH)	17.4	9.6	6.3	5.0	5.9	9.0	8.6	8.0	6.8	6.4	8.7	15.4	17.8	11.0	9.4	14.4	13.0	AV SPEED (MPH)
AV SPEED (M/SEC)	7.8	4.3	2.8	2.2	2.6	4.0	3.8	3.6	3.0	2.9	3.9	6.9	8.0	4.9	4.2	6.4	5.8	AV SPEED (M/SEC)

SOURCE: GEORESEARCH, INC.

Figure IV - 18
Annual Wind Rose
JUDITH GAP — WHEATLAND COUNTY
(1981 - 1985)





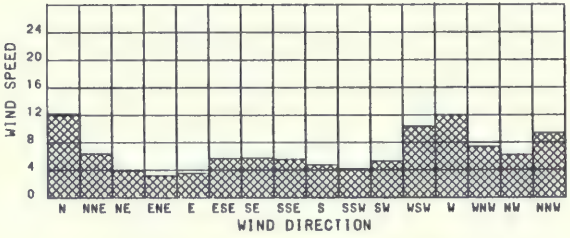


Table IV - 166

Coefficients of Weibull Distribution

WHEATLAND COUNTY - JUDITH GAP

08/06/81 - 07/31/85

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.4533	1.4136
FEBRUARY	7.6730	1.6217
MARCH	6.8146	1.5179
APRIL	6.5247	1.5106
MAY	6.6626	1.6132
JUNE	5.7149	1.6357
JULY	5.4999	1.6946
AUGUST	4.8058	1.9015
SEPTEMBER	5.8041	1.7580
OCTOBER	6.0849	1.4971
NOVEMBER	6.3852	1.5566
DECEMBER	7.4103	1.4924
YEAR	6.3004	1.5767

SOURCE: GEORESEARCH, INC.

BILLINGS NWS AIRPORT

YELLOWSTONE COUNTY

The Billings airport is located on the rimrocks in Billings, at 45 48 00 N and 108 31 48 W (Site No. 139 on Map II-1). Elevation at the airport is 3,582 feet. The Yellowstone River Valley, which is about 400-500 feet deep, lies immediately south of the airport. Elsewhere in the area the land consists of rolling plains. The Bull Mountains, which rise to about 4,700 feet, are located about 30 miles to the north. The Pryor Mountains, with summits of nearly 9,000 feet, lie about 30 miles to the south. About 50 miles to the southwest are the Beartooth Mountains, which rise to over 12,000 feet.

Although most of the land in the area is privately owned, sections owned by the state and the federal governments are scattered throughout the area. The Crow Indian Reservation lies nearby to the south and southeast.

Electrical power in the area is provided by the Montana Power Company, Montana-Dakota Utilities, and the Yellowstone Valley Electric Cooperative. Many transmission lines cross the area.

Billings is the major communications and commercial center in the region. The Billings airport is an important air transportation center.

Meteorological data have been collected at this site for many years by the National Weather Service. These data, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in reporting interval, the data set was broken into three sections for analysis: January 1, 1948, through June 25, 1958; June 26, 1958, through December 31, 1964; and January 1, 1965, through December 31, 1978. Data from the most recent period only were selected for inclusion in the *Montana Wind Energy Atlas.*

The data set for Billings consists of summaries of observations made every third hour from January 1, 1965, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 7.6 meters. The site is representative of a large area of south-central Montana.

Average annual wind speed at the airport was 11.4 miles per hour. Average monthly wind speeds ranged from 9.6 miles per hour in July to 13.4 miles per hour in January.

Average annual wind power was 130.0 watts/m^2. Average monthly wind power varied from 69.0 watts/m^2 in August to 211.0 watts/m^2 in January.

Average seasonal wind speeds were 9.9 miles per hour in summer, 11.3 miles per hour in autumn, 11.4 miles per hour in spring, and 13.2 miles per hour in winter. The highest average wind speeds occurred in mid-afternoon in autumn and winter, and in mid to late afternoon in spring and summer. The lowest average wind speeds occurred around midnight in spring and summer, and during late evening in autumn and winter. The diurnal range of average wind speeds was greatest in summer and least in winter.

The most common wind directions were southwest through west-southwest. Winds from the east-southeast through south-southeast were least common. By direction, average wind speeds varied from 7.2 miles per hour for winds from the south-southeast to 14.3 miles per hour for winds from the west-southwest through west-northwest.

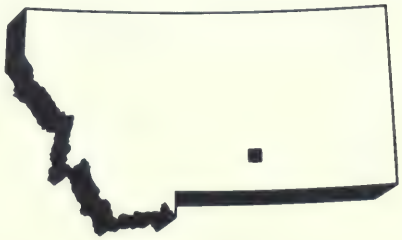


Table IV - 167

Monthly Wind Speed Distribution

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT

01/01/65 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM (<1.1)	1.7	1.6	1.6	1.2	1.3	1.8	2.0	1.1	1.0	1.2	1.4	1.6	1.5
1.1- 3.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
3.4- 5.4	6.6	6.1	7.1	5.8	6.3	7.0	7.2	6.7	6.3	6.2	7.3	6.5	6.6
5.6- 7.6	11.2	11.9	15.8	15.6	16.8	18.7	21.1	22.1	18.8	15.3	14.6	10.9	16.1
7.8- 9.8	13.9	14.8	18.2	21.6	22.3	25.1	28.7	28.9	24.2	20.0	17.1	13.6	20.7
10.1-12.1	11.9	13.2	15.5	17.3	18.0	19.1	18.4	18.8	18.5	16.8	14.8	13.5	16.3
12.3-14.3	11.4	12.2	12.6	12.1	12.6	12.3	10.2	11.1	13.0	14.1	13.8	13.5	12.4
14.5-16.6	11.3	11.7	10.7	9.9	9.6	7.3	6.5	5.8	9.0	10.9	10.0	11.3	9.5
16.8-18.8	13.0	12.0	8.5	8.0	6.6	4.6	3.5	3.1	5.2	8.2	10.3	11.5	7.9
19.0-21.0	8.4	7.8	4.9	3.6	3.3	1.9	1.2	1.2	2.2	3.9	5.5	8.2	4.3
21.3-23.3	5.7	4.9	2.7	2.1	1.8	1.2	0.6	0.6	1.2	1.8	3.1	5.4	2.6
23.5-25.5	2.0	1.3	0.9	1.0	0.6	0.5	0.2	0.2	0.3	0.6	0.8	1.9	0.9
25.7-27.7	1.5	0.8	0.6	0.6	0.2	0.2	0.1	0.1	0.1	0.4	0.7	1.2	0.5
28.0-30.0	0.9	0.8	0.6	0.4	0.2	0.3	0.2	0.1	0.2	0.3	0.4	0.5	0.4
30.2-32.2	0.2	0.4	0.2	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1
32.4-34.4	0.2	0.2	0.1	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
34.7-36.7	0.0	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
41.4-43.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45.9-56.8	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	13.4	13.0	11.6	11.6	11.0	10.3	9.6	9.8	10.5	11.4	12.1	13.2	11.4
AVERAGE SPEED (M/SEC)	6.0	5.8	5.2	5.2	4.9	4.6	4.3	4.4	4.7	5.1	5.4	5.9	5.1
AVERAGE WIND POWER (WATTS/M**2)	211.0	194.0	140.0	134.0	109.0	86.0	70.0	69.0	90.0	120.0	147.0	194.0	130.0

CALM (<0.5)
0.5- 1.4
1.5- 2.4
2.5- 3.4
3.5- 4.4
4.5- 5.4
5.5- 6.4
6.5- 7.4
7.5- 8.4
8.5- 9.4
9.5-10.4
10.5-11.4
11.5-12.4
12.5-13.4
13.5-14.4
14.5-15.4
15.5-16.4
16.5-17.4
17.5-18.4
18.5-19.4
19.5-20.4
20.5-25.4
25.5-30.4
30.5-35.4
35.5-40.4
>40.4

SPEED / HOUR

SPEED / HOUR

ANEMOMETER HEIGHT = 25.0 FEET = 7.6 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 168

Percentage Frequency Summary for Wind Speed

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (WINTER)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	1.6	0.2	7.1	10.7	15.6	12.6	13.6	10.5	12.5	7.0	5.1	1.5	1.1	0.7	0.2	0.2	13.0	5.8
	6	1.4	0.0	6.9	9.9	14.8	13.3	12.8	12.3	13.2	7.3	4.3	1.5	1.5	0.6	0.2	0.1	13.1	5.9
O	9	2.2	0.1	6.2	9.8	12.9	13.0	12.1	12.6	13.2	8.3	6.4	1.1	0.6	0.9	0.4	0.2	13.4	6.0
	12	1.6	0.3	5.8	9.3	12.6	12.8	12.6	10.9	10.8	10.5	7.1	1.8	2.4	0.8	0.4	0.4	14.0	6.3
U	15	1.1	0.1	5.9	10.4	12.8	11.3	11.4	11.5	13.7	9.3	6.0	3.0	1.5	0.7	0.5	0.7	14.1	6.3
	18	1.4	0.0	6.0	13.3	15.2	13.1	12.3	10.6	12.0	7.8	4.5	1.8	0.7	0.4	0.3	0.6	13.0	5.8
R	21	2.1	0.0	6.2	14.2	14.9	12.9	12.0	11.6	11.0	7.3	5.3	1.0	0.6	0.6	0.1	0.1	12.6	5.6
	24	1.7	0.0	7.1	13.0	13.6	13.8	12.3	11.1	10.9	7.4	4.2	2.1	1.0	1.1	0.1	0.3	12.9	5.8
ALL HOURS		1.6	0.1	6.4	11.3	14.1	12.9	12.4	11.4	12.2	8.1	5.3	1.7	1.2	0.7	0.3	0.3	13.2	5.9

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 169

Percentage Frequency Summary for Wind Speed

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (SPRING)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	2.2	0.1	7.8	16.9	23.2	17.1	11.4	10.1	6.2	2.8	1.5	0.1	0.1	0.4	0.1	0.0	10.7	4.8
	6	1.8	0.1	7.6	16.5	21.4	18.8	13.8	8.6	5.6	3.4	1.5	0.3	0.1	0.3	0.1	0.1	10.8	4.8
O	9	1.5	0.0	7.4	16.1	19.0	19.0	12.1	10.3	7.5	4.1	1.6	0.5	0.3	0.2	0.2	0.1	11.3	5.0
	12	1.1	0.0	6.9	16.5	19.2	13.6	10.6	10.5	9.2	5.3	3.2	1.9	0.6	0.5	0.2	0.5	12.1	5.4
U	15	0.5	0.1	4.7	13.3	16.1	14.5	15.6	12.4	9.6	5.0	4.0	1.6	0.9	0.9	0.4	0.5	12.9	5.8
	18	0.5	0.2	3.2	10.9	18.0	17.9	14.2	12.1	11.7	4.9	3.1	1.5	0.8	0.5	0.1	0.5	12.9	5.8
R	21	1.6	0.0	6.0	17.8	25.6	17.8	10.6	7.9	5.9	3.4	1.8	0.5	0.6	0.1	0.1	0.1	10.7	4.8
	24	1.9	0.1	7.7	20.4	23.2	16.7	11.2	8.6	5.9	2.6	0.9	0.3	0.2	0.2	0.1	0.0	10.4	4.6
ALL HOURS		1.4	0.1	6.4	16.1	20.7	16.9	12.4	10.1	7.7	3.9	2.2	0.8	0.5	0.4	0.2	0.2	11.4	5.1

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 170

Percentage Frequency Summary for Wind Speed

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (SUMMER)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4		
		WIND SPEED (M/SEC)																AV SPEED	AV SPEED
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	(MPH)	(M/SEC)
H	3	3.0	0.0	8.3	24.2	26.6	19.4	10.9	4.7	1.7	0.7	0.4	0.0	0.0	0.1	0.0	0.0	9.1	4.1
	6	2.1	0.0	8.2	19.6	29.0	18.8	13.8	5.7	1.9	0.6	0.1	0.1	0.1	0.0	0.0	0.0	9.5	4.2
O	9	2.0	0.0	7.3	19.4	31.1	19.3	10.2	6.4	2.6	1.0	0.2	0.1	0.1	0.2	0.0	0.0	9.5	4.3
	12	1.2	0.0	7.0	22.1	28.5	18.0	9.2	7.0	4.3	1.7	0.9	0.1	0.0	0.1	0.1	0.0	9.8	4.4
U	15	0.8	0.0	6.3	18.5	24.9	18.4	12.1	8.4	5.7	2.3	1.1	1.0	0.5	0.1	0.0	0.1	10.7	4.8
	18	0.6	0.0	4.4	14.7	20.6	19.5	15.4	10.3	7.6	2.8	2.5	0.4	0.4	0.6	0.0	0.3	11.7	5.2
R	21	1.8	0.0	6.0	20.6	29.7	19.0	9.6	6.2	3.7	1.2	0.8	0.6	0.1	0.4	0.0	0.1	9.9	4.4
	24	1.6	0.1	8.4	26.2	30.3	17.6	8.2	3.4	2.2	1.0	0.5	0.3	0.1	0.1	0.0	0.1	9.0	4.0
ALL HOURS		1.6	0.0	7.0	20.7	27.6	18.8	11.2	6.5	3.7	1.4	0.8	0.3	0.1	0.2	0.0	0.1	9.9	4.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 171

Percentage Frequency Summary for Wind Speed

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (AUTUMN)

01/01/65 - 12/31/78

		WIND SPEED (MPH)																
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	
		WIND SPEED (M/SEC)																
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	AV SPEED (MPH)	AV SPEED (M/SEC)
H	3	1.6	0.0	6.5	15.6	21.6	18.6	14.4	9.6	7.5	2.0	1.4	0.4	0.1	0.6	0.1	0.0	11.0	4.9
	6	1.2	0.0	5.3	14.3	19.7	18.7	16.1	11.4	7.4	3.8	1.3	0.3	0.3	0.2	0.0	0.1	11.3	5.1
O	9	1.0	0.1	6.6	13.7	19.9	16.6	17.5	10.1	7.8	3.6	2.4	0.5	0.2	0.0	0.0	0.1	11.4	5.1
	12	0.8	0.1	7.4	14.0	18.7	15.5	13.6	9.2	10.5	5.0	2.9	0.7	0.9	0.5	0.2	0.1	11.9	5.3
U	15	0.6	0.1	6.4	14.8	16.8	13.7	12.3	13.2	9.7	6.1	3.0	1.3	1.3	0.6	0.2	0.3	12.5	5.6
	18	1.2	0.0	6.5	15.2	22.7	17.2	12.6	10.7	6.8	4.0	1.8	0.6	0.1	0.3	0.1	0.2	11.3	5.0
R	21	1.5	0.0	7.1	22.2	23.1	15.4	10.3	7.8	6.7	3.6	1.4	0.5	0.2	0.1	0.1	0.0	10.5	4.7
	24	1.8	0.0	7.1	19.9	20.8	17.9	12.2	7.9	6.7	3.2	1.9	0.3	0.1	0.2	0.0	0.1	10.6	4.7
ALL HOURS		1.2	0.0	6.6	16.2	20.4	16.7	13.6	10.0	7.9	3.9	2.0	0.6	0.4	0.3	0.1	0.1	11.3	5.1

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 172

Annual Wind Rose Distribution

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT

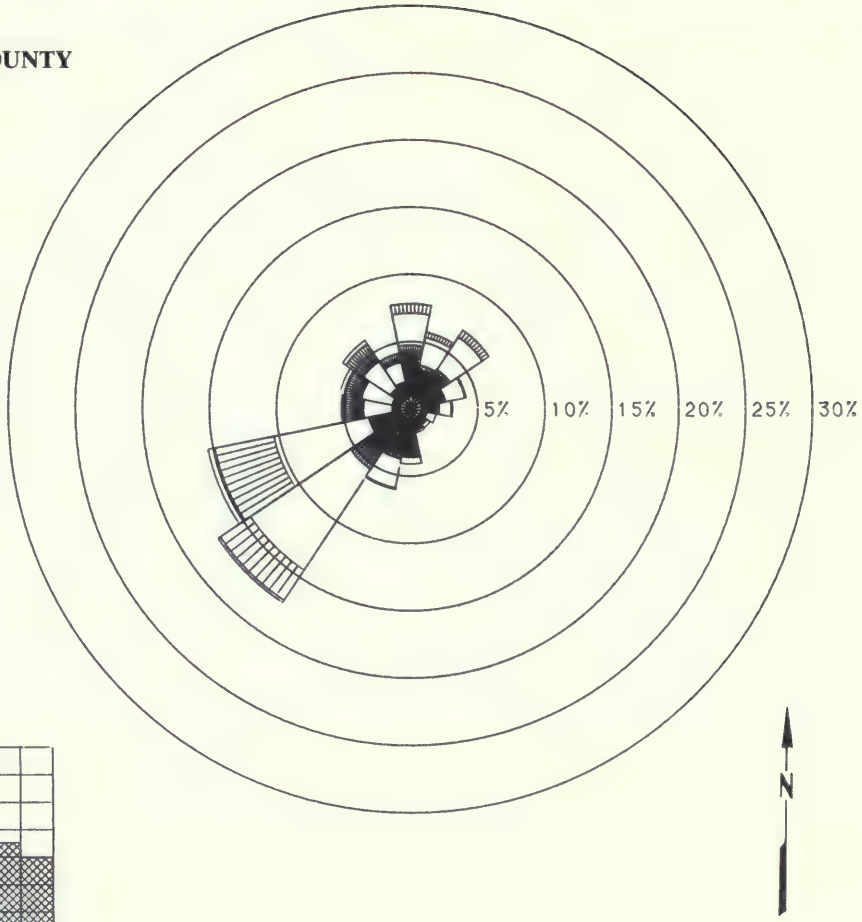
01/01/65 - 12/31/78

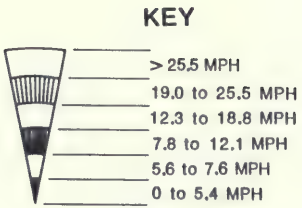
DIRECTION> / SPEED (MPH)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION / SPEED (M/SEC)
1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4
3.4- 5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5- 2.4
5.6- 7.6	0.9	0.6	0.6	0.5	0.4	0.2	0.3	0.3	0.6	0.4	0.4	0.3	0.2	0.2	0.3	0.4	6.6	2.5- 3.4
7.8- 9.8	1.9	1.2	1.2	1.0	0.8	0.5	0.6	0.8	1.6	1.3	1.6	1.0	0.5	0.5	0.6	0.8	15.9	3.5- 4.4
10.1-12.1	1.9	1.5	1.7	1.1	0.9	0.5	0.5	0.5	1.4	2.1	3.4	1.9	0.7	0.7	0.9	0.8	20.5	4.5- 5.4
12.3-14.3	1.2	1.0	1.4	0.8	0.6	0.4	0.2	0.2	0.4	1.4	3.7	2.3	0.7	0.9	0.8	0.6	16.6	5.5- 6.4
14.5-16.6	0.7	0.6	0.9	0.5	0.2	0.2	0.1	0.0	0.1	0.6	3.1	2.6	0.7	0.7	0.8	0.5	12.3	6.5- 7.4
16.8-18.8	0.5	0.5	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.2	2.2	2.3	0.7	0.7	0.8	0.4	9.3	7.5- 8.4
19.0-21.0	0.4	0.2	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.1	1.5	2.4	0.6	0.7	0.8	0.4	7.7	8.5- 9.4
21.3-23.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.3	0.4	0.4	0.5	0.2	4.0	9.5-10.4
23.5-25.5	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.8	0.4	0.3	0.3	0.1	2.6	10.5-11.4
25.7-27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.6	11.5-12.4
28.0-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.6	12.5-13.4
30.2-32.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.4	13.5-14.4
32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5-15.4
34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
CALM																	1.5	CALM
TOTAL	7.9	5.8	7.0	4.3	3.3	1.9	1.8	1.8	4.2	6.0	17.3	15.6	5.2	5.5	6.4	4.5	100.0	TOTAL
AV SPD (MPH)	9.8	10.1	10.3	9.2	8.7	9.2	8.1	7.2	7.6	9.4	12.5	14.3	14.3	14.3	14.1	11.9	10.7	AV SPD (MPH)
AV SPD (M/S)	4.4	4.5	4.6	4.1	3.9	4.1	3.6	3.2	3.4	4.2	5.6	6.4	6.4	6.4	6.3	5.3	4.8	AV SPD (M/S)

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

MILES/HOUR

Figure IV - 19
Annual Wind Rose
BILLINGS NWS AIRPORT — YELLOWSTONE COUNTY
(1965 - 1978)





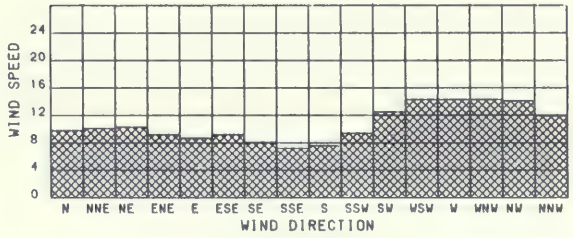


Table IV - 173

Coefficients of Weibull Distribution

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT

01/01/65 - 12/31/78

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.7220	2.9830
FEBRUARY	7.3980	3.1830
MARCH	6.8560	3.2820
APRIL	7.5060	2.7540
MAY	6.0330	2.4200
JUNE	5.6440	2.5900
JULY	5.4440	2.3910
AUGUST	5.4340	2.4310
SEPTEMBER	5.8100	2.4890
OCTOBER	6.1670	2.5460
NOVEMBER	6.8720	3.3120
DECEMBER	7.5440	3.0810
YEAR	6.1590	2.4710

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

CUSTER FAA AIRPORT

YELLOWSTONE COUNTY

The Custer airport is located about 1 mile northeast of Custer at 46 09 00 N and 107 31 00 W (Site No. 142 on Map II-1). Elevation at the airport site is 2,880 feet. Meteorological data were collected at this site for a short time in the late 1940s and early 1950s by the Federal Aviation Administration.

These data, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the data set was broken into two parts for analysis: January 1, 1948, through May 31, 1949; and June 1, 1949, through May 30, 1950. Only data from the latter of the two periods were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Custer consists of summaries derived from hourly observations made from June 1, 1949, through May 30, 1950. The anemometer was mounted on a rooftop at a height of 10.1 meters.

Average monthly wind speeds at the site varied from 7.6 miles per hour in August to 10.5 miles per hour in April. Average annual wind speed was 8.7 miles per hour.

Average monthly wind power ranged from 49.0 watts/m^2 in August to 137.0 watts/m^2 in April. Average annual wind power was 79.0 watts/m^2.

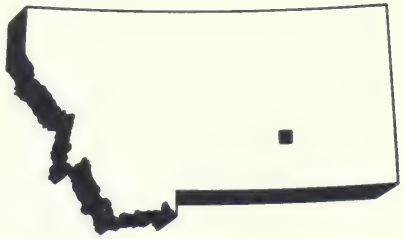


Table IV - 174

Monthly Wind Speed Distribution

YELLOWSTONE COUNTY - CUSTER FAA AIRPORT

06/01/49 - 05/30/50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	5.5	7.3	4.3	4.0	2.7	1.7	3.2	3.5	5.3	2.7	1.8	3.9	3.9	CALM (<0.5)
1.1- 3.1	9.0	7.5	8.6	5.7	7.1	7.6	8.7	9.0	9.6	5.2	6.1	7.4	7.7	0.5- 1.4
3.4- 5.4	21.4	23.7	18.8	16.5	22.0	24.9	25.4	25.6	25.4	20.3	23.6	20.8	22.4	1.5- 2.4 S
S 5.6- 7.6	13.2	15.8	13.0	11.1	12.5	13.2	16.7	19.1	18.6	12.6	19.6	16.0	15.2	2.5- 3.4 P
P 7.8- 9.8	12.2	12.7	9.9	14.7	10.1	14.7	15.9	17.0	10.7	13.4	13.7	15.1	13.5	3.5- 4.4 E
E 10.1-12.1	25.1	20.0	23.9	20.1	24.6	19.3	16.8	15.7	15.0	20.0	14.6	20.4	19.4	4.5- 5.4 E
E 12.3-14.3	5.9	4.9	7.3	3.5	8.3	4.9	3.1	2.0	4.4	6.0	3.7	4.6	4.7	5.5- 6.4 D
D 14.5-16.6	4.4	5.1	5.8	5.1	5.6	5.0	3.4	3.0	4.0	5.8	4.7	4.3	4.6	6.5- 7.4
16.8-18.8	2.6	1.9	4.3	7.6	3.6	4.5	2.4	2.2	3.1	5.8	3.9	2.3	3.7	7.5- 8.4 M
M 19.0-21.0	0.4	0.6	1.9	5.8	2.1	2.5	2.0	1.7	1.8	4.6	2.6	3.0	2.4	8.5- 9.4 E
I 21.3-23.3	0.3	0.3	0.8	1.9	1.5	0.8	0.3	0.1	0.6	0.9	1.2	0.8	0.8	9.5-10.4 T
L 23.5-25.5	0.0	0.0	0.3	1.2	0.0	0.3	1.1	0.4	0.7	1.2	1.1	0.7	0.6	10.5-11.4 E
E 25.7-27.7	0.0	0.1	0.4	0.8	0.0	0.3	0.1	0.4	0.6	0.4	1.2	0.5	0.4	11.5-12.4 R
S 28.0-30.0	0.0	0.0	0.1	0.8	0.0	0.1	0.9	0.3	0.3	0.4	0.6	0.3	0.3	12.5-13.4 S
/ 30.2-32.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.1	13.5-14.4 /
H 32.4-34.4	0.0	0.1	0.4	0.6	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	14.5-15.4 S
O 34.7-36.7	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	8.1	7.8	9.2	10.5	8.9	8.7	8.1	7.6	7.8	9.8	9.4	8.7	8.7	
AVERAGE SPEED (M/SEC)	3.6	3.5	4.1	4.7	4.0	3.9	3.6	3.4	3.5	4.4	4.2	3.9	3.9	
AVERAGE WIND POWER (WATTS/M**2)	53.0	52.0	87.0	137.0	68.0	70.0	63.0	49.0	62.0	108.0	125.0	74.0	79.0	

ANEMOMETER HEIGHT = 33.0 FEET = 10.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

LAUREL NEW FARM

YELLOWSTONE COUNTY

The Laurel New Farm site is located about 2 miles east of Laurel at 45 40 07 N and 108 44 25 W (Site No. 145 on Map II-1). Elevation at the site is 3,270 feet. The site was established by the Montana Air Quality Bureau to measure concentrations of particulates and sulfur dioxide.

Wind data collected during the period from November 13, 1980, through May 17, 1982, were available for analysis. The data set contains hourly averages of wind speed and wind direction recorded by a data acquisition system that scanned each parameter several times per minute. The measurement device was a Climatronics electronic anemometer and wind vane on a 10-meter tower.

Winds were monitored long enough to adequately represent the wind resource at the location. Because the site sits on a level valley floor, the data are representative of the immediate area only. Data recovery ranged from 25.7 percent in August to 99.8 percent in February and April. Overall data recovery was 81.9 percent.

Average annual wind speed at the site was 7.8 miles per hour. Average monthly wind speeds ranged from 4.3 miles per hour in August to 9.5 miles per hour in February.

Average annual wind power was 63.6 watts/m^2. Average monthly wind power values ranged from 8.6 watts/m^2 in September to 96.0 watts/m^2 in February.

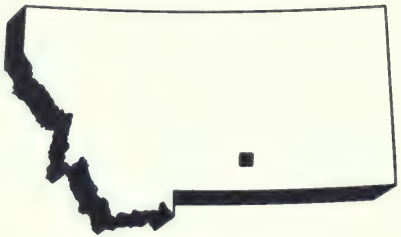


Table IV - 175

Monthly Wind Speed Distribution

YELLOWSTONE COUNTY - LAUREL NEW FARM

11/13/80 - 05/17/82

SPEED (MPH)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	SPEED (MPH)
CALM	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.5	0.4	2.4	0.1	2.5	0.6	CALM
0.1-1.0	1.8	0.9	1.1	0.5	0.9	0.3	0.3	2.6	1.6	1.4	1.5	4.7	1.6	0.1- 0.4
1.1-2.0	6.3	2.8	4.9	2.6	6.5	4.5	3.9	15.7	9.7	7.3	4.0	4.9	5.1	0.5- 0.9
2.1-3.0	9.3	7.5	11.7	7.7	11.9	10.7	15.5	17.3	23.1	13.5	11.3	8.6	10.8	1.0- 1.3
3.1-4.0	8.1	7.0	11.3	8.1	8.7	11.0	16.5	15.2	20.5	10.5	7.0	7.6	9.5	1.4- 1.8
4.1-5.0	7.8	7.6	11.2	10.2	12.3	14.6	16.5	19.4	12.1	12.0	7.2	7.6	10.1	1.9- 2.2
5.1-6.0	6.0	6.0	7.3	8.5	10.2	6.9	12.4	6.8	9.7	6.5	5.7	4.8	7.2	2.3- 2.7
6.1-7.0	9.2	7.2	7.7	8.6	10.4	7.2	10.3	7.3	8.3	9.9	9.0	6.1	8.3	2.8- 3.1
7.1-8.0	6.6	5.3	5.7	6.4	5.5	6.0	5.2	3.7	4.4	4.9	6.5	4.9	5.6	3.2- 3.6
8.1-9.0	7.2	7.2	8.3	6.5	6.6	5.4	4.9	4.2	4.8	7.8	7.0	6.6	6.8	3.7- 4.0
9.1-10.0	5.9	5.1	4.2	5.6	4.5	3.9	2.3	3.7	2.4	3.2	5.1	5.3	4.7	4.1- 4.5
10.1-11.0	4.9	7.0	6.2	5.3	4.5	4.5	2.8	1.6	1.6	4.1	5.3	5.7	5.1	4.6- 4.9
11.1-12.0	4.0	4.4	4.1	4.2	3.4	3.9	2.3	0.5	0.6	3.2	3.3	4.2	3.7	5.0- 5.4
12.1-13.0	4.4	6.3	3.9	3.7	2.6	4.8	2.3	1.0	0.4	1.7	6.0	4.1	3.9	5.5- 5.8
13.1-14.0	4.1	4.0	2.7	3.3	2.3	3.3	1.3	0.0	0.2	3.6	3.6	5.1	3.3	5.9- 6.3
14.1-15.0	4.1	5.1	2.2	4.7	2.4	2.4	1.6	0.0	0.2	1.8	4.3	4.5	3.4	6.4- 6.7
15.1-16.0	2.6	3.5	1.9	2.9	1.4	2.4	0.5	0.0	0.0	1.5	2.1	2.4	2.2	6.8- 7.2
16.1-17.0	1.7	2.6	0.8	2.5	1.5	1.2	0.5	0.0	0.0	1.2	2.3	2.6	1.8	7.3- 7.6
17.1-18.0	1.9	2.8	0.7	2.2	0.7	1.8	0.5	0.0	0.0	1.4	2.1	2.6	1.7	7.7- 8.0
18.1-19.0	1.0	1.9	0.6	1.7	0.4	0.9	0.3	0.5	0.0	1.1	1.9	1.3	1.1	8.1- 8.5
19.1-20.0	1.3	1.9	0.8	1.5	0.6	1.8	0.0	0.0	0.0	0.6	1.2	1.4	1.1	8.6- 8.9
20.1-25.0	1.7	3.0	1.1	2.0	2.4	2.7	0.0	0.0	0.0	0.5	3.3	1.8	1.8	9,0-11.2
25.1-30.0	0.1	1.0	1.3	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.6	11.3-13.4
30.1-35.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	13.5-15.6
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE SPEED (MPH)	8.1	9.5	7.6	8.8	7.1	7.8	5.7	4.3	4.4	6.5	8.6	8.3	7.8	
AVERAGE SPEED (M/SEC)	3.6	4.2	3.4	3.9	3.2	3.5	2.5	1.9	1.9	2.9	3.8	3.7	3.5	
AVERAGE WIND POWER (WATTS/M**2)	64.6	96.0	66.2	81.2	47.9	59.3	20.4	9.9	8.6	37.9	75.5	79.4	63.6	
PERCENT DATA RECOVERY	76.2	99.8	95.8	99.8	88.6	46.5	52.0	25.7	69.9	88.4	79.3	99.7	81.9	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
NUMBER OF OBSERVATIONS = 10830
PERCENTAGE DATA RECOVERY = 81.9

SOURCE: GEORESEARCH, INC.

SHAWNEE PARK

YELLOWSTONE COUNTY

The Shawnee Park air monitoring site is located in a residential area approximately 6 miles northeast of downtown Billings at 45 49 28 N and 108 23 56 W (Site No. 149 on Map II-1) near the intersection of Interstate 94 and Interstate 90. Elevation at the park is 3,123 feet. The site was established by the Montana Air Quality Bureau to measure concentrations of ozone and sulfur dioxide in the area.

Wind data have been collected at the site since January 22, 1981. Data through April 30, 1982, were available for analysis. The data set contains hourly averages for wind speed and direction manually reduced from strip-chart records. The wind measuring instrument was a Meteorology Research, Inc., mechanical recording anemometer and wind vane set on the monitoring trailer roof 4 meters above ground level.

Winds were monitored long enough to adequately represent the wind resource at the location. Data recovery was greater than 80 percent, except during March and from August through October. Overall data recovery was 74.2 percent. Since the site is located in a residential area on the Yellowstone Valley floor, the data are representative only of the immediate area.

Average annual wind speed was 5.9 miles per hour. Average monthly wind speeds varied from 4.5 miles per hour in August to 7.1 miles per hour in April.

Average monthly wind power ranged from 8.9 watts/m^2 in September to 45.4 watts/m^2 in April. Average annual wind power was 28.2 watts/m^2.

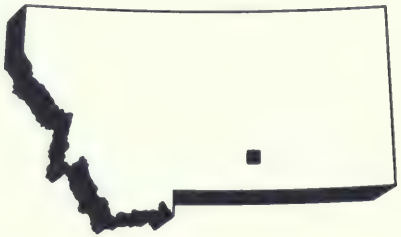


Table IV - 176

Monthly Wind Speed Distribution

YELLOWSTONE COUNTY - SHAWNEE PARK

01/22/81 - 04/30/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
CALM	1.5	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
0.1-1.0	1.0	0.8	0.5	0.8	0.7	0.6	0.6	1.0	0.5	1.7	0.6	0.0	0.7
1.1-2.0	10.0	6.3	8.1	5.9	7.8	6.8	5.4	11.7	6.8	8.7	11.0	7.8	7.8
2.1-3.0	14.4	10.7	19.9	11.3	13.7	12.0	14.0	17.9	11.8	20.3	16.4	20.8	14.4
3.1-4.0	11.6	11.7	14.4	10.1	14.8	14.0	21.3	15.1	22.7	13.0	15.3	16.5	13.8
4.1-5.0	10.4	11.1	10.4	9.3	15.1	12.9	12.3	16.1	17.7	12.1	14.4	12.7	12.1
5.1-6.0	10.8	8.7	9.2	11.1	9.9	12.8	11.9	11.4	15.5	8.2	15.3	10.8	11.1
6.1-7.0	9.8	10.6	9.3	8.0	9.1	9.0	7.9	8.9	8.2	10.8	9.3	6.5	9.0
7.1-8.0	5.4	7.9	5.9	6.9	7.3	6.4	8.6	6.7	6.4	5.6	5.7	7.1	6.8
8.1-9.0	3.9	7.5	4.7	5.8	5.9	6.1	6.5	4.0	4.5	4.3	1.9	3.0	5.1
9.1-10.0	3.4	3.9	3.3	5.7	3.4	4.0	3.6	3.5	3.2	4.3	2.9	2.0	3.8
10.1-11.0	3.6	3.2	3.6	4.6	3.0	3.3	2.5	2.0	1.8	2.6	1.7	2.5	3.1
11.1-12.0	3.0	2.9	1.4	3.4	2.2	3.1	1.5	0.2	0.0	1.7	1.1	2.2	2.3
12.1-13.0	2.9	2.8	1.7	3.6	1.3	1.8	0.8	1.0	0.5	1.3	1.1	1.6	2.1
13.1-14.0	2.3	2.4	1.7	2.8	1.1	1.1	1.0	0.0	0.5	2.2	1.5	1.2	1.7
14.1-15.0	1.6	2.7	1.4	2.2	1.3	2.2	0.6	0.0	0.0	0.9	0.8	1.4	1.6
15.1-16.0	1.7	1.6	0.7	2.0	0.7	1.1	0.2	0.2	0.0	1.3	0.6	0.9	1.1
16.1-17.0	0.9	0.9	0.5	2.2	0.8	1.4	0.2	0.2	0.0	0.0	0.3	0.9	1.0
17.1-18.0	0.8	1.3	0.9	0.8	0.9	0.7	0.2	0.0	0.0	0.9	0.0	0.4	0.7
18.1-19.0	0.5	1.5	0.2	1.0	0.8	0.1	0.6	0.0	0.0	0.0	0.1	0.4	0.6
19.1-20.0	0.1	0.5	0.5	0.9	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.4
20.1-25.0	0.3	0.5	1.7	1.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5
25.1-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE SPEED (MPH)	5.8	6.7	5.7	7.1	5.7	6.0	5.2	4.5	4.7	5.2	4.8	5.2	5.9
AVERAGE SPEED (M/SEC)	2.6	3.0	2.5	3.2	2.5	2.7	2.3	2.0	2.1	2.3	2.2	2.3	2.6
AVERAGE WIND POWER (WATTS/M**2)	29.6	39.2	31.7	45.4	23.7	25.6	15.7	9.6	8.9	18.9	14.1	27.1	28.2
PERCENT DATA RECOVERY	90.1	86.8	38.8	99.1	100.0	99.9	64.3	54.2	30.6	31.1	100.0	93.0	74.2

CALM
0.1- 0.4
0.5- 0.9
1.0- 1.3
1.4- 1.8
1.9- 2.2
2.3- 2.7
2.8- 3.1
3.2- 3.6
3.7- 4.0
4.1- 4.5
4.6- 4.9
5.0- 5.4
5.5- 5.8
5.9- 6.3
6.4- 6.7
6.8- 7.2
7.3- 7.6
7.7- 8.0
8.1- 8.5
8.6- 8.9
9,0-11.2
11.3-13.4
13.5-15.6
15.7-17.9
>17.9

SPEED / HOUR

SEPTEMBER

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
NUMBER OF OBSERVATIONS = 8266
PERCENTAGE DATA RECOVERY = 74.2

SOURCE: GEORESEARCH, INC.

POWER LAW ANALYSES

Power Law Analyses in General

Wind speed data are available in most cases for only one anemometer height — generally 10 meters above ground level. Since wind speed normally increases with height above the ground, and since most wind energy generation systems have hub heights of more than 10 meters, some means of estimating the wind speed at heights other than the measurement height is needed.

The two most common methods of estimating wind speed at hub height from measurements at a reference level are (1) to assume a logarithmic wind profile, and (2) to assume a power law. The empirically derived power law is used more often, although the logarithmic law is theoretically more sound since it is based on the principles of fluid mechanics.

To derive an expression for the logarithmic wind profile, Businger et al. (1971) and others have assumed that the variation of wind speed with height can be treated as a function of stability and surface roughness only. Drawbacks to the use of the logarithmic wind profile are the difficulties in measuring the friction velocity and the stability parameter.

Most investigators, therefore, have used a power law wind profile instead of the logarithmic profile. The power law is expressed as:

$$U_2 = U_1 \left(\frac{Z_2}{Z_1} \right)^{\alpha}$$

where:

U_2 = wind speed at height Z_2;
U_1 = wind speed at height Z_1;
Z_2 = computed height;
Z_1 = reference height;
α = power law exponent.

The power law exponent (α) is a function of surface roughness and stability. Empirical studies have found that an α value of 0.14 (1/7) best fits most sites. This method, therefore, is often referred to as the "one-seventh" power law.

Power Law Analyses of Montana Wind Data

GeoResearch, Inc., has performed power law analyses of wind data available from sites where monitoring was conducted at several heights. The purpose of these analyses was to compare application of the one-seventh law to use of the calculated power law exponent.

One year of data from the Livingston Candidate Wind Turbine site and 18 months of data from the Montana Power Company Salem site were analyzed. In addition, previously analyzed data from the Old West Regional Commission's monitoring site at Glasgow Air Force Base were examined and compared to the Livingston and Salem data.

The power law analyses involved calculating the power law exponent for each hour by means of the following equation:

$$\alpha = \frac{\log \left(\frac{U_{up}}{U_{low}} \right)}{\log \left(\frac{Z_{up}}{Z_{low}} \right)}$$

where:

α = power law exponent;
log = base 10 logarithm;
U = wind speed;
Z = anemometer height.

"Up" and "low" refer to the upper and lower anemometer heights, respectively.

The power law exponents were calculated for two different air layers: lowest to middle, and lowest to highest anemometer heights. Once all exponents were calculated, the monthly and yearly arithmetic mean and standard deviation of all

values for each hour were computed as follows:

$$\bar{\alpha} = \frac{1}{n} \sum_{i=1}^{n} \alpha_i$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} \alpha_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} \alpha_i\right)^2}{n-1}}$$

where:

$\bar{\alpha}$ = mean of α values;
σ = standard deviation;
n = number of α values.

Results of the analyses are listed in Tables V-1 through V-4. As a consequence of the great variation in wind speed over any given period, the standard deviations are quite large. Though not included in these tables, additional calculations showed that the average α values were highest during the nighttime hours and lowest during the afternoon for all months. This relationship was most pronounced during the summer.

An examination of the tables indicates that, at the Salem site, average monthly α values for the 10- to 30-meter anemometer heights ranged from 0.08 in December to 0.16 in July and November. The annual average value was 0.14. For the 10 - to 100 - meter heights, average monthly values of α ranged from 0.09 in December to 0.19 in November, with an annual average of 0.14.

At the Livingston site, average monthly α values for the 9.1 - to 30.0 - meter heights ranged from 0.07 in May to 0.39 in February. The annual average α value was 0.13. For the 9.1- to 45.7-meter heights, monthly average α values varied from 0.12 in December to 0.35 in February, with an annual average of 0.18.

Data from a wind monitoring site at Glasgow Air Force Base were previously analyzed to determine variation of wind speed with height by Pasquill stability category and by wind direction. Results of these analyses indicate average α values of about 0.10 for neutral and unstable conditions,

Table V-1
Power Law Exponents (Monthly Average)
Montana Power Company Salem Site
5/1/80 - 10/31/81

Month	Alpha 10.0-30.0m	Sigma 10.0-30.0m	Alpha 10.0-100.0m	Sigma 10.0-100.0m
January	0.12	0.22	0.18	0.21
February	0.14	0.15	0.16	0.14
March	0.12	0.24	0.13	0.19
April	0.14	0.15	0.14	0.16
May	0.13	0.19	0.12	0.16
June	0.15	0.17	0.16	0.14
July	0.16	0.33	0.15	0.21
August	0.13	0.19	0.12	0.17
September	0.13	0.19	0.13	0.18
October	0.15	0.24	0.17	0.19
November	0.16	0.17	0.19	0.16
December	0.08	0.25	0.09	0.17
Year	0.14	0.22	0.14	0.18

and from about 0.23 to 0.40 during stable conditions. Thus, applying the one-seventh law under unstable and neutral conditions would result in an overestimation of wind speeds aloft. Under stable conditions, however, the one-seventh law would underestimate actual wind speeds aloft. In general, stable and neutral conditions primarily occur during the period shortly before sunset until shortly after sunrise. Unstable conditions are more likely during the summer than in the winter.

The effect of using actual monthly power law exponents instead of the one-seventh exponent is

Table V-2
Power Law Exponents (Annual Average)
Montana Power Company Salem Site
5/1/80 - 10/31/81

Hour of Day	Alpha 10-30m	Sigma 10-30m	Alpha 10-100m	Sigma 10-100m
1	0.17	0.30	0.18	0.23
2	0.17	0.32	0.18	0.22
3	0.17	0.31	0.18	0.23
4	0.17	0.27	0.18	0.23
5	0.17	0.23	0.19	0.19
6	0.16	0.21	0.17	0.20
7	0.17	0.27	0.18	0.20
8	0.16	0.22	0.20	0.19
9	0.13	0.23	0.17	0.18
10	0.11	0.21	0.14	0.15
11	0.10	0.16	0.10	0.15
12	0.08	0.16	0.09	0.12
13	0.06	0.16	0.07	0.11
14	0.07	0.14	0.08	0.10
15	0.08	0.11	0.08	0.09
16	0.09	0.11	0.08	0.07
17	0.10	0.12	0.09	0.10
18	0.11	0.13	0.10	0.13
19	0.12	0.14	0.11	0.14
20	0.15	0.17	0.14	0.15
21	0.17	0.19	0.17	0.16
22	0.19	0.23	0.19	0.20
23	0.17	0.26	0.18	0.19
24	0.19	0.26	0.19	0.21
All Hours	0.14	0.22	0.14	0.18

shown for the Salem Site and the Livingston Candidate Wind Turbine Site in Tables V-5 through V-8. In these tables, the monthly averages of the measured wind speed readings at each anemometer height are given, together with the wind speed at that level computed from the actual average wind speed measured at the lowest height. Two power law exponents were used: the actual average power law exponent calculated from the data, and the one-seventh power law.

Use of the actual power law exponent and the one-seventh power law produced about the same

Table V-3
Power Law Exponents (Monthly Average)
Livingston Candidate Wind Turbine Site
9/1/80 - 6/30/82

Month	Alpha 9.1-30.0m	Sigma 9.1-30.0m	Alpha 9.1-45.7m	Sigma 9.1-45.7m
January	0.12	0.10	0.13	0.14
February	0.39	0.59	0.35	0.45
March	0.15	0.22	0.14	0.12
April	0.11	0.09	0.15	0.12
May	0.07	0.11	0.19	0.12
June	0.13	0.10	0.18	0.12
July	0.12	0.11	0.20	0.14
August	0.13	0.13	0.23	0.16
September	0.11	0.11	0.17	0.15
October	0.12	0.09	0.15	0.15
November	0.10	0.11	0.13	0.12
December	0.10	0.06	0.12	0.08
Year	0.13	0.21	0.18	0.19

level of accuracy. (See Tables V-9 and V-10.) The major exception was in February; however, the collected data at the lower height could be inaccurate. The one-seventh power law tended to be somewhat more accurate over longer than shorter periods.

Table V-4
Power Law Exponents (Annual Average)
Livingston Candidate Wind Turbine Site
9/1/80 - 6/30/82

Hour of Day	Alpha 9.1-30.0m	Sigma 9.1-30.0m	Alpha 9.1-45.7m	Sigma 9.1-45.7m
1	0.16	0.20	0.20	0.19
2	0.15	0.21	0.20	0.19
3	0.15	0.20	0.19	0.19
4	0.15	0.21	0.19	0.20
5	0.14	0.22	0.18	0.21
6	0.15	0.21	0.19	0.21
7	0.14	0.22	0.18	0.21
8	0.15	0.21	0.18	0.19
9	0.12	0.21	0.17	0.19
10	0.12	0.25	0.15	0.17
11	0.09	0.16	0.14	0.14
12	0.11	0.25	0.15	0.20
13	0.11	0.23	0.15	0.19
14	0.10	0.23	0.14	0.18
15	0.11	0.20	0.14	0.16
16	0.11	0.22	0.15	0.18
17	0.12	0.19	0.15	0.16
18	0.12	0.17	0.16	0.15
19	0.13	0.15	0.17	0.14
20	0.15	0.18	0.19	0.16
21	0.16	0.20	0.20	0.18
22	0.15	0.21	0.20	0.19
23	0.17	0.22	0.21	0.20
24	0.17	0.22	0.21	0.20
All Hours	0.13	0.21	0.18	0.19

Table V-5

Actual vs Calculated Wind Speeds

Montana Power Company Salem Site - 30 Meters

(miles per hour)

Month	Actual	Actual Exponent	1/7 Power Law
January	9.4	9.1	9.4
February	16.1	16.1	16.1
March	9.6	9.8	10.1
April	15.0	15.2	15.2
May	10.2	10.0	10.2
June	12.0	11.9	11.8
July	10.7	10.7	10.5
August	9.1	9.0	9.1
September	11.4	11.3	11.5
October	12.9	12.9	12.8
November	16.2	16.2	15.9
December	16.3	15.6	16.7
Year	11.9	11.9	11.9

Table V-6

Actual vs Calculated Wind Speed

Montana Power Company Salem Site - 100 Meters

(miles per hour)

Month	Actual	Actual Exponent	1/7 Power Law
January	12.7	12.1	11.1
February	20.3	19.9	19.2
March	12.1	11.6	11.9
April	18.1	17.9	18.1
May	11.8	11.5	12.1
June	14.6	14.6	14.0
July	12.7	12.7	12.5
August	10.7	10.3	10.8
September	13.8	13.2	13.6
October	16.4	16.1	15.1
November	20.8	21.1	18.9
December	17.5	17.6	19.9
Year	14.5	14.1	14.2

Table V-7
Actual vs Calculated Wind Speeds
Livingston Candidate Wind Turbine Site - 30 Meters
(miles per hour)

Month	Actual	Actual Exponent	1/7 Power Law
January	20.0	20.4	21.0
February	25.4	33.0	24.5
March	19.2	15.1	14.9
April	16.7	16.9	17.5
May	12.1	12.0	13.0
June	13.6	13.8	14.0
July	13.8	12.7	14.1
August	11.1	11.1	11.3
September	13.0	12.9	13.4
October	17.3	17.4	17.9
November	22.4	21.7	22.9
December	26.2	26.3	27.6
Year	18.1	18.2	18.5

Table V-8
Actual vs Calculated Wind Speeds
Livingston Candidate Wind Turbine Site - 45.7 Meters
(miles per hour)

Month	Actual	Actual Exponent	1/7 Power Law
January	22.7	21.8	22.3
February	26.5	36.4	26.1
March	20.5	15.8	15.9
April	18.2	18.9	18.6
May	14.4	14.9	13.9
June	15.3	15.8	14.9
July	15.7	16.4	15.0
August	13.2	13.8	12.0
September	14.7	14.9	14.2
October	19.0	19.2	19.0
November	22.8	23.8	24.3
December	27.4	28.3	29.3
Year	19.5	20.9	19.6

Table V-9
Accuracy of Power Law Exponents
Montana Power Company Salem Site
(Percentage Difference From Actual Speed)

	30 Meters		100 Meters	
Month	Actual Exponent	1/7 Power Law	Actual Exponent	1/7 Power Law
January	-3	—	-5	-13
February	—	—	-2	-5
March	2	5	-4	-2
April	1	1	-1	—
May	-2	—	-3	3
June	-1	-2	—	-4
July	—	-2	—	-2
August	-1	—	-4	1
September	-1	1	-4	-1
October	—	-1	-2	-8
November	—	-2	1	-9
December	-4	2	1	14
Year	—	—	-3	-2

Table V-10
Accuracy of Power Law Exponents
Livingston Candidate Wind Turbine Site
(Percentage Difference From Actual Speed)

	30 Meters		45.7 Meters	
Month	Actual Exponent	1/7 Power Law	Actual Exponent	1/7 Power Law
January	2	5	-4	-2
February	30	-4	37	-2
March	-21	-22	-23	-22
April	1	5	4	2
May	-1	7	3	-3
June	1	3	3	-3
July	-1	2	4	-4
August	—	2	5	-9
September	-1	3	1	-3
October	1	3	1	—
November	-3	2	4	7
December	—	5	3	7
Year	1	2	7	1

Appendix A

Wind Measurement in General

The quality of wind data depends on the monitoring device selected, how the instrument is sited, how accurately it is calibrated, and how well it is maintained. The methods used to screen the raw data, as well as the methods used to assess the data once in edited form, also contribute to the quality of the final data.

Wind Measurement Devices

Many types of wind-measuring systems are commercially available. Most are ruggedly constructed, designed for a wide variety of applications, and require little attention for operation and maintenance. Such devices have been used for many years to measure winds in Montana.

The most common types of wind monitoring devices are anemometers, wind vanes, and combination wind sensors.

Anemometers measure wind speed. Commercially available anemometers operate on a variety of physical principles. Rotational cup and propeller anemometers are the most commonly used wind speed sensors. More esoteric designs generally are used only for very specialized studies.

Wind direction sensors, commonly called "wind vanes," operate by wind exerting pressure on a surface that rotates about a fulcrum. Although the standard vane measures only the horizontal wind direction, the bi-directional vane is free to move not only horizontally but also vertically (plus or minus 50 degrees or more from the horizontal). The shape and design of the vane surface will vary with the manufacturer.

Two types of sensors combine both wind speed and wind direction measuring capabilities into a single mechanical device. The propeller-vane sensor measures two-dimensional flow; the propeller-bivane sensor measures three-dimensional flow. Simple trigonometry is used with these wind component anemometers to determine wind speed and direction.

Varieties of these wind measuring instruments and their operational principles are presented in Table A-1.

Site Location

The most important siting considerations are anemometer height and spacing in relation to obstructions. The meteorological variables measured by the anemometer obviously are affected by large-scale surface features.

The effect of cities has been studied extensively. Documented effects include a decrease in average wind speed, a decrease in atmospheric stability, an increase in turbulence, an increase in temperature, and changes in precipitation patterns. These changes, of course, will affect the evaluation and interpretation of meteorological and air quality data collected in an urban area.

The effects of mountains and valleys on wind continue to be studied. Well-known effects include the channeling of flow up or down a valley, the creation of drainage flow, the establishment of lee-waves, and an increase in turbulence generated by friction.

The important point is that almost any physical object has an effect on the wind. In fact, it is difficult to find a site that is completely free of obstructions. This being the case, the choice of a site for collecting meteorological data that will be most representative of an area must be made with a complete understanding of the meteorological parameters being investigated, the large-scale geographic area, the vertical structure of the atmosphere, and the potential uses of the data.

Once a location is chosen, the characteristics of

Table A-1
Types of Wind Sensors and Their Operational Principles

Physical Principle	Wind Sensor Type	Measurement
Rotation	Cups	Horizontal speed
	Vane-oriented Propeller	Horizontal speed
	Bivane-oriented Propeller	Total speed
	Fixed Propeller	Three-dimensional components on perpendicular axes
Pressure	Plate	Horizontal speed
	Tube	Horizontal speed
	Bridled cups	Horizontal speed
Cooling	Hot wire	Directional flow component
	Hot thermopile	Directional flow component
	Hot film	Directional flow component
Sound	Sonic	Directional flow component
Vortex-shedding	Vane-oriented shape	Horizontal speed
Ion-flow	Transport	Horizontal speed

the site should be completely documented. This should include complete site descriptions, topographic maps, photographs of the site, and a description of the area that is adequately represented by the site. Attention to this last point is very important, for it will allow a more rational interpretation of the data by subsequent investigators. The documentation might state, for example, that a site adequately represents a certain section of a particular valley, the urban part of a given city, or several rural counties. The nature and purpose of the site, in any event, should be clearly described to assist those who may use the data.

Instrument Calibration

Wind sensors should be calibrated when they are installed and every six months thereafter. Calibration also is required after the sensors are repaired. The user's manual accompanying the measurement device generally will specify the calibration methods to be followed. Most systems will require a DC voltage input which represents some output value. In other cases, they may require a frequency to represent some output value. Many systems have a built-in calibration unit to test part of the system.

Wind vanes must be oriented to true north when installed. This orientation must be checked at least once every six months. In addition, the sensors must be set so that they are absolutely vertical.

Instrument Maintenance

A sound, preventive maintenance program for the sensors also should be established. The equipment should be checked for potential problems at least once a month. The manufacturer's recommendations for maintenance and parts replacement also should be followed.

Data Screening

Once data are collected, they should be reviewed to screen out possible incorrect data points before they are put into accessible storage or passed on to the users. While the purpose of a quality assurance program is to avoid generating

bad data, it is impossible to do so completely. Even in the best planned and best conducted programs, undetected errors can be generated by faulty equipment, noisy data transmission lines, faulty key punching, and a myriad of other causes. In both automatic and manual data screening, the most obvious checks should be performed first. These checks should include making sure that the data actually exist and are properly identified, and that forms and files are filled out properly.

Methods of editing or screening meteorological data usually involve comparing the measured values with an expected value or range of values. Techniques for checking the measured values usually fall into one or more of the following categories:

- Comparison with upper and/or lower limits on the allowed range of data;
- Comparison with known statistical distributions of the data;
- Comparison with spatial and/or temporal data fields;
- Comparison based on known physical relationships.

If data do not pass a validation procedure, the screener has two basic choices: (1) to eliminate the questionable data from the file; or (2) to flag it for further examination. Automatically discarding data is a feasible option if the screening procedure is carefully designed and each datum is not of high value. Records must be kept of all discarded data, so that the reason for the fault may later be found and corrected. With flagged data, the screener must examine the data and decide whether they are acceptable for use. If data are deemed unacceptable, it may be possible to correct them. If any values are corrected, this should be noted in the data file. Alternatively, data of questionable value may be kept in the data file under a flagged status, with a notation of why they are thought to be questionable. The user can then decide whether he or she wants to use these data. The collecting agency, however, typically is in the best position to make a decision on the validity of the data.

Data Interpretation

To assess the wind energy potential of an area, it often is necessary to evaluate data collected by different agencies, at different times, using different methods. When comparing data sets, the most important factors to consider are:

- The periods of time during which the data were collected;
- The locations of the monitoring sites;
- The anemometer heights;
- The methods used to collect and analyze the data;
- The averaging periods of the data;
- The quality assurance procedures followed.

The period of time represented by the data is important because wind speed and direction vary from year to year. Ideally, at least five years of data should be available to characterize the long-term wind climatology of an area. When comparing data from different sites, it is best if the data are for the same period of time; otherwise, the comparison may be biased due to the interannual variability of the wind.

It is important to know the physical characteristics of a site because of the strong influence that topography has on wind direction and speed. Knowledge of an area's topography and possible obstructions to air flow is useful in determining the wind regimes that influence an area (see Chapter III).

Anemometer height is of critical importance when comparing wind data from different sites because wind speed usually increases with height. If different sites have different anemometer heights, it may be useful to adjust the wind speed values to a standard reference height by means of the one-seventh power law. Power laws, however, give only an approximation of wind speed variation with height, not actual values (see Chapter V).

The methods used to collect and analyze the data also should be known when comparing data from different sites. Computerized data acquisition systems, which measure wind speed and wind direction every few seconds, generally give more accurate results than manual reduction of data from stripchart records.

To compare wind data sets, the data averaging time also must be known. Most data sets represent one-hour averages of wind speed and direction, although some monitoring studies gather and organize data differently, with averaging times of seconds or minutes. Users must be particularly cautious when a data point representing a period of only a few minutes is said to represent a complete hour.

Finally, the quality assurance procedures followed should be examined. Of particular importance are the methods and frequency of equipment calibration and the detection and treatment of erroneous data values.

Appendix B

METHODOLOGY

Data Collection

GeoResearch, Inc., developed the *Montana Wind Energy Atlas* by assembling, at the outset, a comprehensive wind data base. This data base is the most complete of its kind existing for Montana. Major data sets obtained include those from the following sources:

- The Montana Air Quality Bureau (AQB) maintains a large data file, which includes wind speed and wind direction data, as well as data for many other meteorological and air quality parameters. Most of the data were gathered by the AQB as part of studies conducted to measure air quality in Montana. Some of the data were collected by private companies and submitted to the AQB to comply with air quality permit regulations.
- The Bureau of Reclamation (BOR), U.S. Department of the Interior, operated five wind monitoring sites in Montana as part of its Northern Great Plains Wind Energy Study. These data were obtained for use in preparing the *Montana Wind Energy Atlas*. BOR later reduced data from the sites run by the Montana Department of Natural Resources and Conservation (DNRC).
- The National Climatic Center (NCC) in Asheville, North Carolina, provided wind data gathered by the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the United States Air Force (USAF). These agencies have collected wind speed and wind direction data at airports for many years. The data are collected primarily for aviation and weather forecasting purposes. Wind speed and wind direction data are collected each hour and disseminated over a nationwide data gathering system. These data are intended to represent a mean value of wind speed and wind direction during the minute preceding the observation.
- The Battelle Pacific Northwest Laboratory, under a contract with the U.S. Department of Energy, obtained the NWS, FAA, and USAF data from the National Climatic Center and analyzed these data. Selected Battelle analyses were used in preparing the *Montana Wind Energy Atlas*. Battelle Pacific Northwest Laboratory also provided one year of wind monitoring data from the Livingston Candidate Wind Turbine site. The Livingston data include hourly wind speed and wind direction averages at 10.0, 30.0, and 45.7 meters above ground level. These data have been analyzed and included as part of the *Montana Wind Energy Atlas*.
- The Montana Power Company provided 18 months of data from their Salem site. The Salem data include hourly wind speed and wind direction averages at 10.0, 30.0, and 100.0 meters above ground level. These data also have been analyzed and included as part of the *Montana Wind Energy Atlas*.
- The Bonneville Power Administration (BPA) provided hourly data on three sites in their Wind Regional Energy Assessment Program (REAP). These data are in the data base at the Wind Resources Assessment Laboratory, Oregon State University.

In addition to these data, available in machine-readable form, a considerable amount of useful data was obtained in hard copy from other sources.

Data from these previous monitoring efforts were examined and evaluated. When the data files were examined, data from some sites were found to contain a significant number of errors. If a site was located in an area of low potential and other monitoring sites were nearby, data from that site were not analyzed. If no sites were nearby, the data set was screened and efforts were made to

delete invalid data. If after this a significant amount of the data remained suspect, the data from the site were not analyzed.

Preliminary analyses were conducted, when feasible, for all sites with a solid data set. Detailed analyses then were performed for all sites that indicated a high wind potential. These various analyses are discussed below.

Data Analyses

Several types of wind analyses were performed for all sites except those previously analyzed by Battelle. For those sites, the Battelle analysis simply was reproduced. The extent of the analysis for a particular site depended on whether the site was considered "high potential." For purposes of this *Atlas,* a site was defined as "high potential" if the average annual wind speed at that site was equal to or greater than 11 miles per hour.

An initial screening analysis was performed by computer on all sites for which at least one year of wind speed data was available. The result of this screening was a table showing a percentage frequency distribution of wind speed by month and a similar annual distribution. The analysis also provided information on average monthly and average annual wind speed and power.

To perform the analysis, each hourly wind speed value was evaluated and a running total of the variable representing the appropriate wind speed class was maintained. After all wind speed values had been read, the percentage frequencies of each wind speed class for all 13 periods (monthly plus annual) were computed by dividing the count for the class by the total number of readings for the period and multiplying the result by 100.

This computer program also calculated average monthly and average annual wind speeds by summing the individual wind speeds and dividing this sum by the total number of readings. To obtain the average monthly and average annual wind power values, the sum of the wind speed cubed was obtained from the data file. Once these monthly sums were obtained, the average wind speed cubed was calculated by dividing this sum by the number of observations. The average wind power was then calculated from:

$$\bar{P} = 1/2\, \rho\, \bar{V}^3$$

where:

$\bar{P}$ = average wind power (watts/m^2);
ρ = air density (kg/m^3) = 0.3488 (station pressure (mb))/(station temperature (K));
$\bar{V}^3$ = average wind speed cubed.

Since temperature and pressure at the monitoring sites were not available for this analysis, average values were used. For pressure, the value used was computed from:

$$P = P_o\,(1\text{-}0.0226z)^{5.25}$$

where:

P = station pressure;
P_o = standard sea-level pressure;
z = station elevation (km).

For temperature, average statewide values for each month were used. Table B-1 lists the pressure values for each site, while Table B-2 shows the temperature values for each month. (The Battelle analysis, since it was limited to NWS, FAA, and USAF weather stations, was able to use actual temperature and pressure data.)

Finally, anemometer height, the total number of valid observations, and the percentage of data recovery were presented for each site.

For the Livingston Candidate and Salem sites, where the wind speed actually was measured at higher levels, average wind speed and wind power were calculated using the same method used for the 10-meter tables. In addition, for these sites actual power law exponents were calculated for comparison with the one-seventh power law. Methodology and results of these power law analyses are presented in Chapter V.

Once the preliminary screening analysis was complete, the tables were examined to determine those sites to be further analyzed as high potential sites.

The first analysis performed for the high potential sites was the calculation of percentage frequency distributions of wind speed by hour and by season. In these tables, accompanying the discussion of these sites (Chapter IV), hourly periods are listed according to the time (Mountain Standard Time) at which the given period ended (e.g., hour 1 represents the time period 0001 - 0100, etc.). The four seasons are defined as:

- Winter — December, January, and February
- Spring — March, April, and May
- Summer — June, July, and August
- Autumn — September, October, and November

To analyze these distributions, a wind speed class was computed, and a running total was kept of the variable representing that class, hour, and season. In addition, the sum of wind speeds for each hour and season was computed. Once all wind speed values for a site had been read, the percentage frequencies for each wind speed class,

Table B-1

Sites Analyzed for the Montana Wind Energy Atlas

Average Station Pressure (millibars)

County	Site	Pressure
Big Horn	Decker Coal #8	892
	Spring Creek #1	880
	Westmoreland Absaloka #2	890
Broadwater	Three Forks	859
Cascade	Salem	898
Chouteau	Highwood Bench	905
Daniels	Scobey Border	926
	SCOBEY HANRAHAN	915
Dawson	GLENDIVE MICROWAVE	921
Deer Lodge	ANACONDA C-HILL	776
	Anaconda Highway Junction	840
	Anaconda Mill Creek	837
	ANACONDA WEATHER HILL	800
Flathead	Big Prairie	888
	Columbia Falls Water Supply	904
Glacier	CUT BANK	888
Jefferson	Microwave Tower	863
Lake	Ronan Nine Pipes	907
Missoula	Missoula Hoerner-Waldorf #1	903
	Missoula University of Montana	901
Park	LIVINGSTON CANDIDATE WIND TURBINE SITE	834
Powder River	Broadus Randall Ranch	904
Rosebud	COLSTRIP BN	900
	Western Energy #12	891
Silver Bow	Butte Hebgen Park	827
Teton	Choteau	852
Valley	Fort Peck	931
Wheatland	JUDITH GAP	852
Yellowstone	Laurel New Farm	901
	Shawnee Park	904

NOTE: Capitalized site names indicate high potential sites.

Table B-2

Sites Analyzed for the Montana Wind Energy Atlas

Monthly and Annual Average Temperature (degrees Kelvin)

January	264	July	293
February	268	August	292
March	272	September	287
April	276	October	281
May	283	November	276
June	287	December	268
	Year 280		

hour, and season were computed, and the average wind speed for each hour and season was calculated. A frequency distribution and an average speed for all hours also were calculated.

A second analysis performed for high potential sites was the calculation of an annual joint frequency distribution of wind speed and wind direction (the wind rose distribution). To perform the analysis, matching wind speed and direction values were read from the data file. A wind speed class and a wind direction class were calculated, and running totals of variables representing different wind speed and direction categories were kept. After all data had been read, percentage frequencies of each category were computed by dividing the count for each class by the total count.

A measured wind speed distribution, such as those provided in this *Atlas,* may be approximated by an analytical distribution such as the Rayleigh distribution:

$$p(V) = \frac{\pi V}{2\bar{V}^2} \exp\left[\frac{-\pi V^2}{4\bar{V}^2}\right]$$

where:

$p(V)$ = probability density of wind speed (fraction per m/sec);
V = wind speed;
$\bar{V}$ = long term average wind speed.

The Rayleigh distribution is a special case of the Weibull distribution. This more complicated distribution, in many cases, provides a better approximation of the measured wind speed distribution. The Weibull distribution is given by:

$$p(V) = \left(\frac{k}{c}\right)\left(\frac{V}{c}\right)^{k-1} \exp\left\{-\left(\frac{V}{c}\right)^{k}\right\}$$

where:

$p(V)$ = probability density of wind speed (fraction per m/sec)
c = scale factor related to the mean wind speed ($\bar{V}$) by
$\bar{V}$ = $c\,\Gamma(1+1/k)$, where:
Γ = the gamma function, $\Gamma(n) = (n-1)!$, and
k = shape factor related to the variance of wind speed (σ_V^2) by
$\sigma_V^2 = c^2\{\Gamma(1+2/k) - [\Gamma(1+1/k)]\}^2$

For the high potential sites in this *Atlas,* the Weibull parameters c and k have been calculated from the monthly wind speed distributions by means of a least-squares fit to the observed distribution. This method requires that wind speed categories be of equal size. The data files from which the percentage frequency for wind speed categories was obtained, however, contain wind speed categories of unequal size: one mile per hour increments between 0 and 20 miles per hour; five mile per hour increments between 20 and 40 miles per hour; and a final category of wind speeds exceeding 40 miles per hour. For wind speeds between 20 and 40 miles per hour, therefore, the wind speed frequency for each five mile per hour increment was divided by five, assuming an equal distribution over that increment. For wind speeds greater than 40 miles per hour, the category was assumed to be centered on 42.5 miles per hour.

The method of differential corrections was used to fit values of c and k to the observed wind speed frequency distribution derived from the data file. This is an iterative method in which the values of the Weibull probability density function and its derivatives with respect to c and k are computed from an initial guess of c and k. From these values, corrections are computed and added to c and k. The process is repeated several times until accurate values of c and k are obtained.

These Weibull coefficients are useful primarily for meteorological modeling purposes.

Site Selection

Analyzed sites were selected for inclusion in Chapter IV of the *Atlas* according to the following criteria:

- All high potential sites (e.g., those with average annual wind speeds greater than or equal to 11 miles per hour) were included;
- In general, sites with less wind potential also were included when one year's data or more were available, except that in areas with many sites, such as Missoula and Anaconda, one or two representative sites were selected to characterize the wind potential in the area;
- Sites with low data completeness generally were not included. If a more complete data set for the area was not available, however, a site with low data completeness was included, with caveats, based on the assumption that some data for the area are better than none.

Sites not included in Chapter IV of the *Atlas,* either for lack of a solid data set for analysis or for the reasons outlined above, are discussed briefly in Appendix C.

Appendix C

Additional Wind Monitoring Sites

The comprehensive wind data base from which the *Atlas* was prepared covers 158 wind monitoring sites in Montana. Of these sites, 56 were selected for detailed analysis in the *Montana Wind Energy Atlas,* according to criteria discussed in Appendix B.

Appendix C briefly discusses the other sites, by monitoring agency.

Montana Air Quality Bureau

Table C-1 lists additional wind monitoring sites operated by the Montana Air Quality Bureau or by private entities reporting data to the bureau. In most cases, less than one year's data are available for these sites. In a few cases, the data are no longer on file with AQB, and in a few others, the data are available only in hard-copy form.

NWS/FAA/USAF

Most of the data sets for the NWS/FAA/USAF sites have been split into two or more time periods for analysis. This was done due to a change in anemometer height or a change in reporting period. If analyses for more than one monitoring period were available, the longest period, typically the most recent as well, was selected for inclusion in Chapter IV. Those analyses not presented in Chapter IV are listed in Table C-2. In addition, no data summaries are presented for the Havre and Glasgow NWS city offices since, in both cases, a more representative airport site is located nearby.

Table C-1
Additional Montana Air Quality Bureau Wind Monitoring Sites

Site No.	Site	County	Reason For Exclusion From Atlas
3	Hardin	Big Horn	Data in hard copy only
4	Hardin MDN	Big Horn	Data in hard copy only
12	Great Falls City Sewage Pump	Cascade	Data no longer on file
13	Great Falls Kiwanis Park	Cascade	Less than one year's data
16	Portage	Cascade	Data no longer on file
22	Scobey Richardson	Daniels	Less than one year's data
26	Anaconda #2 Pond Discharge	Deer Lodge	Other representative site
28	Anaconda County Airport	Deer Lodge	Other representative site
30	Anaconda Lincoln School	Deer Lodge	Other representative site
32	Anaconda Water Office	Deer Lodge	Other representative site
34	Anaconda West Gate	Deer Lodge	Less than one year's data
35	Antelope	Deer Lodge	Data no longer on file

Table C-1

Additional Montana Air Quality Bureau Wind Monitoring Sites (cont'd.)

Site No.	Site	County	Reason for Exclusion from Atlas
36	Kucera	Deer Lodge	Data no longer on file
37	Opportunity Main Street	Deer Lodge	Data no longer on file
38	Poor Farm	Deer Lodge	Data in hard copy only
39	Tailings Pond	Deer Lodge	Data no longer on file
42	Bigfork Ranger Station	Flathead	Less than one year's data
43	Columbia Falls Brandt	Flathead	Less than one year's data
44	Columbia Falls Delbon	Flathead	Other representative site
45	Columbia Falls Geis	Flathead	Less than one year's data
46	Columbia Falls Water Supply (Trailer)	Flathead	Data in hard copy only
47	Kalispell Airport	Flathead	Other representative site
49	Polebridge	Flathead	Less than one year's data
50	Big Sky Golf Course	Gallatin	Less than one year's data
64	Polson	Lake	Other representative site
65	Ronan	Lake	Other representative site
68	East Helena A & W	Lewis & Clark	Other representative site
70	Hadfield West Main (ASARCO)	Lewis & Clark	Less than one year's data
72	Kleffner Residence	Lewis & Clark	Data in hard copy only
73	Kleffner Road (ASARCO)	Lewis & Clark	Less than one year's data
74	Sinter Plant (ASARCO)	Lewis & Clark	Less than one year's data
75	Water Tower (ASARCO)	Lewis & Clark	Less than one year's data
76	Zinc Plant (ASARCO)	Lewis & Clark	Less than one year's data
80	Missoula Fire Lab	Missoula	Other representative site
82	Missoula Lions Park	Missoula	Other representative site
83	Missoula Malfunction Junction	Missoula	Other representative site
85	Missoula Olofson	Missoula	Other representative site
86	Missoula Rose Park	Missoula	Other representative site
87	Missoula Stiegler	Missoula	Other representative site
104	Powell County Courthouse	Powell	Data in hard copy only
106	Poplar	Roosevelt	Less than one year's data
110	Colstrip McRae	Rosebud	Other representative site
112	Lame Deer-Fisher Butte	Rosebud	Less than one year's data
116	Butte Alpine West	Silver Bow	Less than one year's data
119	Harrison Fire Station	Silver Bow	Data no longer on file
128	Devon	Toole	Data no longer on file
129	Fort Peck	Valley	Data no longer on file
135	Billings AQB Office	Yellowstone	Data in hard copy only
136	Billings 11th & 27th	Yellowstone	Less than one year's data
137	Billings Central Park	Yellowstone	Less than one year's data
138	Billings Metra	Yellowstone	Other representative site
140	Billings Taft School	Yellowstone	Other representative site
141	Coburn Road	Yellowstone	Data no longer on file
143	Laurel BN	Yellowstone	Data no longer on file
144	Laurel Farm	Yellowstone	Other representative site
146	Lockwood Park	Yellowstone	Data no longer on file
147	Lockwood School	Yellowstone	Less than one year's data
148	North Johnson Lane	Yellowstone	Data no longer on file

Department of Natural Resources and Conservation

The Montana Department of Natural Resources and Conservation (DNRC) funded a two-year wind energy research and development program. The purpose of this project was to monitor winds at three locations (Livingston, Whitehall, and Big Timber) and to install a wind turbine at Livingston.

Monitoring equipment was installed at the monitoring sites in February and March 1980. Data were collected at an anemometer height of 10 meters using equipment from Campbell Scientific Corporation. A microprocessor collected the data and recorded it on magnetic tape at the site. The data were later transferred to a computer for storage and analysis. Raw data from these sites were available only in hard copy at the time computer analyses for this *Atlas* were conducted. A summary of one year's data, however, was available. Wind speed and wind power summaries are presented below. Wind speed figures are as collected at the 10-meter anemometer height, whereas wind power figures are calculated for 55 feet above ground level.

The Whitehall site was located approximately 4 miles west of Whitehall. Average monthly wind speeds at the site ranged from 7.0 miles per hour in January 1981 to 14.7 miles per hour in December 1980. Average wind speed for the year of monitoring was 10.6 miles per hour. Average wind power varied from 20 watts/m^2 in January 1981 to 187 watts/m^2 in December 1980. Average annual wind power was 81 watts/m^2.

The Big Timber site was located approximately 4 miles east of Big Timber. Average monthly wind speeds ranged from 8.0 miles per hour in May 1980 to 15.8 miles per hour in February 1981. Average wind speed for the year of monitoring was 10.5 miles per hour. Average monthly wind power density varied from 30 watts/m^2 in May

Table C-2
Additional NWS/FAA/USAF Wind Monitoring Periods and Sites

Site	County	Period of Monitoring		
Dillon FAA Airport	Beaverhead	06/19/51	-	10/29/63
Great Falls Malmstrom AFB	Cascade	01/01/49	-	05/31/53
Great Falls Malmstrom AFB	Cascade	03/01/54	-	02/28/58
Great Falls NWS Airport	Cascade	01/01/48	-	02/02/59
Great Falls NWS Airport	Cascade	02/03/59	-	12/31/64
Miles City FAA Airport	Custer	01/01/48	-	12/31/64
Lewistown FAA Airport	Fergus	12/21/49	-	08/15/62
Kalispell NWS Airport	Flathead	05/01/49	-	06/30/53
Kalispell NWS Airport	Flathead	07/01/53	-	06/30/59
Kalispell NWS Airport	Flathead	07/01/59	-	06/30/64
Bozeman FAA Airport	Gallatin	01/01/48	-	04/27/51
Cut Bank FAA Airport	Glacier	11/22/49	-	10/03/59
Drummond FAA Airport	Granite	01/01/48	-	10/15/50
Havre NWS Airport	Hill	02/01/61	-	12/31/64
Havre NWS City	Hill	05/01/50	-	10/31/56
Helena NWS Airport	Lewis & Clark	01/01/48	-	09/19/61
Missoula NWS Airport	Missoula	01/01/48	-	04/03/58
Missoula NWS Airport	Missoula	04/04/58	-	12/31/64
Livingston FAA Airport	Park	07/05/53	-	12/31/54
Glasgow AFB	Valley	10/01/58	-	06/07/61
Glasgow NWS Airport	Valley	10/01/55	-	08/05/62
Glasgow NWS Airport	Valley	08/06/62	-	05/31/68
Glasgow NWS City	Valley	01/01/48	-	10/31/55
Billings NWS Airport	Yellowstone	01/01/48	-	06/25/58
Billings NWS Airport	Yellowstone	06/26/58	-	12/31/64
Custer FAA Airport	Yellowstone	01/01/48	-	05/31/49

1980 to 234 watts/m² in February 1981. Average wind power for the year of monitoring was 80 watts/m².

The Livingston site was located approximately 2 miles east of Livingston. Average monthly wind speeds ranged from 13.2 miles per hour in August 1980 to 21.5 miles per hour in February 1981. Average wind speed during the year of monitoring was 15.8 miles per hour. Average monthly wind power density ranged from 95 watts/m² in July 1980 to 790 watts/m² in December 1980. For the year of monitoring, average wind power was 277 watts/m².

Wind speed at these sites reportedly was unusually low that year compared with historical wind speeds.

The Montana Department of Natural Resources and Conservation also funded a three-phase, one-year survey of wind speed and direction in the upper Yellowstone River Valley, between Livingston and Springdale.

During each phase of the study, wind data were collected at three sites for three months. Phase 1 ran from December 1978 through February 1979; Phase 2 was conducted in March and April 1979; Phase 3 took place from May through July 1979. Monitoring and analysis was conducted by Brelsford Engineering of Bozeman.

Each site was equipped with wind monitoring systems from Natural Power, Inc. (NPI). Sensors were mounted on 10-meter towers. The monitoring sites for this study were located as follows:

Phase 1

S1A—Harvatt's Flat—2 miles south of Livingston, south of I-90 on the eastern bench above the Yellowstone, and 6 miles west of the Livingston Municipal Airport (Mission Field).

S1B—Koffee Kup Ranch—10 miles northeast of Livingston on a hilltop 1 mile east of the Shields River and 5 miles north of the Yellowstone River.

S1C—Hunter's Hot Springs—3 miles northeast of Springdale, 16 miles east of Livingston, and 2 miles north of the Yellowstone River on a hilltop west of the hot springs.

Phase 2

S2A — Park County Landfill — 4 miles east of Livingston, south of I-90 on the bench above Chicken Creek and the Yellowstone River Valley, and 2 miles west of Mission Field.

S2B — George Meyers Ranch — 1 mile southeast of Livingston, north of I-90 on the north shoulder of Harvatt's Flat and adjacent to the abandoned Livingston Airport.

S2C — Charles Hillman Ranch — 6 miles northeast of Livingston on the west side of the Shields

Table C-3

DNRC Wind Energy Survey

Livingston to Springdale

Site	Month/Year	Mean Wind Speed (mph)	Available Power (watts/m²)
S1A	Dec 78	20.4	701.9
S1A	Jan 79	13.8	337.6
S1A	Feb 79	19.5	689.4
S1B	Jan 79	7.7	83.9
S1B	Feb 79	14.6	373.4
S1C	Jan 79	16.7	448.3
S1C	Feb 79	16.7	443.6
S2A	Mar 79	14.9	334.1
S2A	Apr 79	16.0	376.2
S2B	Mar 79	10.7	151.3
S2B	Apr 79	12.2	169.3
S2C	Apr 79	12.9	153.9
S2C	May 79	12.6	171.9
S3A	May 79	13.7	235.8
S3A	Jun 79	12.1	163.1
S3A	Jul 79	10.4	96.1
S3B	Jun 79	13.8	217.5
S3C	May 79	12.9	247.3
S3C	Jun 79	12.7	230.6
S3C	Jul 79	10.9	122.3

River Valley as it enters the Yellowstone River Valley west of U.S. 89.

Phase 3

S3A — Livingston West — 2 miles west of Livingston, north of I-90 and south of U.S. 10, on a hill above the Leonard Adams home.

S3B — McGuire Hill — 1/2 mile northeast of Livingston and 1/4 mile north of the residential area on the abandoned police radio tower hill.

S3C — Gordon Brittan Ranch — 9 miles west of Livingston and 1.5 miles south of the Yellowstone River on the east bench above Mission Creek and the Brittan Ranch home.

A DNRC summary of mean wind speed and available power for these sites is presented in Table C-3. Monthly mean wind speeds ranged from about 8 to 20 miles per hour, and averaged about 14 miles per hour. Monthly available wind power ranged from about 100 to 700 watts per square meter and averaged about 300 watts per square meter.

Old West Regional Commission

The Old West Regional Commission funded a one-year study to establish the solar and wind energy potential and the atmospheric dispersion potential in northeastern Montana.

A 100-meter meteorological tower was installed at Glasgow Air Force Base, about 20 miles north of Glasgow, in September 1977. Wind measurements were made at three levels (10.0, 31.6, and 100.0 meters above ground level) from October 25, 1977, to August 31, 1978.

Wind speeds at the 10-meter level averaged 11.4 miles per hour during the study. Average monthly wind speeds ranged from 9.2 miles per hour in March 1978 to 15.4 miles per hour in April 1978.

At the 31.6-meter level, average wind speed during the period of study was 13.9 miles per hour. Average monthly wind speeds varied from 11.6 miles per hour in March 1978 to 18.3 miles per hour in April 1978.

The average wind speed at the 100-meter level was 17.4 miles per hour during the study period. Average monthly wind speeds ranged from 15.0 miles per hour in June 1978 to 21.7 miles per hour in April 1978.

The raw data from this site were available only in hard copy form at the time computer analyses were conducted for this *Atlas*. Data analyses from monitoring previously conducted at this site by the U.S. Air Force also are provided in the *Atlas*. The wind speeds observed in the more recent study were considerably higher than those reported by the Air Force; however, they were similar to those reported by the National Weather Service at the airport about 20 miles south.

U.S. Department of the Interior, Bureau of Reclamation

The Bureau of Reclamation, at that time the Water and Power Resources Service of the U.S. Department of the Interior, funded a one-year study to monitor wind speed and direction at four sites in Montana. Monitoring sites were established at the Canyon Ferry, Gibson, Tiber, and Yellowtail dams. Monitoring began in January 1980 and continued through January 1981.

The monitors used were Met One wind speed and direction sensors mounted 10 meters above ground level. A Campbell Scientific CR21 data logger sampled the sensors every 60 seconds and recorded hourly averages on cassette tape. Parameters measured included: current wind speed; current wind direction; average wind speed; average wind direction and constancy; average wind speed to the first, second, third, fourth, and fifth power; maximum wind speed; and minimum wind speed. The data tapes were read by computer, checked, and stored for later processing.

The wind power speeds reported in the data summaries are not based on hourly average wind speeds, but are the cube root of the hourly average cubed wind speed.

The Canyon Ferry site was located on the summit of a hill just north of Canyon Ferry Dam at an elevation of 4,150 feet. Average monthly wind power speeds at the site ranged from 7.8 miles per hour in January 1981 to 14.1 miles per hour in November 1980. The average wind power speed for the monitoring period was 10.1 miles per hour.

The Gibson Dam site was located just south of the Sun River approximately 3.5 miles east-northeast of Gibson Dam. Elevation at the site was 4,460 feet. Average monthly wind power speeds ranged from 9.4 miles per hour in January 1981 to 17.9 miles per hour in September 1980. The average wind power speed for the monitoring period was 12.5 miles per hour.

The Tiber Dam site was located approximately 0.5 mile east-northeast of Tiber Dam at an elevation of 3,240 feet. Average monthly wind power speeds varied from 7.8 miles per hour in February 1980 to 13.0 miles per hour in December 1980. The average wind power speed for the monitoring period was 10.6 miles per hour.

The Yellowtail Dam site was located approximately 0.8 miles north-northwest of the

Yellowtail Dam at an elevation of 3,800 feet. Average monthly wind power speeds ranged from 9.6 miles per hour in January 1981 to 16.3 miles per hour in October 1980. The average wind power speed for the monitoring period was 12.1 miles per hour.

The raw data from this study were not available for analysis since the Bureau of Reclamation did not have the data in its possession.

Western Area Power Administration

The Western Area Power Administration (WAPA) ran a Wind Prospecting Program beginning in 1981. The program covered ten of the states in WAPA's fifteen-state marketing area. Over one hundred sixty sites eventually were studied; six of the sites were located in Montana. Monitoring at some of the Montana sites continued until 1986.

WAPA recruited its customers (rural electric cooperatives in Montana's case) to carry out the actual data collection. Five co-ops participated in Montana. The program collected 15-minute average wind speed data. Aeolian Kinetics or Natural Power signal conditioners were used and the raw data were recorded on cassette tape.

Data from this effort were available only in hard copy. Data tables from the WAPA report have been reproduced for the *Wind Atlas*. Brief site descriptions also have been drawn from WAPA reports. No information was available on the quality control measures in the program.

The Ekalaka site was located in extreme southeastern Montana, about nine miles northeast of Ekalaka, at 45 57 37 N and 104 25 18 W (Site No. 11 on Map II-1). Elevation was 3,460 feet. The area is rolling grasslands. The anemometer was located at a substation. Anemometer height was 36 feet. Data was collected between March 11, 1982 and May 18, 1986, by Southeast Electric Cooperative. Average wind speed was 9.78 miles per hour. Highest average wind speed was in the spring at 10.57 miles per hour and lowest was in the fall, at 9.05 miles per hour. Data recovery for the entire period was 69 percent.

The Circle site was located 17 miles southeast of Circle, at 47 15 42 N and 105 16 05 W (Site No. 23 on Map II-1). Elevation was 3,467 feet. The site is on a high ridge, approximately 1,000 feet higher than the surrounding area. There were no obstructions in this grassland area. Anemometer height was 31 feet. Data was collected between March 11, 1982 and October 30, 1985 by the McCone Electric Cooperative. Average wind speed was 14.63 miles per hour. Highest average wind speed was in the spring, at 15.49 miles per hour, and lowest was 14.01 in the fall. Data recovery for the entire period was 78 percent.

The Mt. Antione site was located 5 miles southeast of Hays, at 47 57 20 N and 108 33 02 W (Site No. 158 on Map II-1). The anemometer was located on the highest point in the Little Rocky Mountains, with no obstructions. The elevation was 5,785 feet. The anemometer height was 30 feet. Data were collected between February 8, 1984 and August 5, 1985; the monitoring system was in place until a later date, but no more valid data were collected. Average wind speed was 13.98 miles per hour. Highest average wind speed was during the winter, with 15.77 miles per hour, while the lowest was in the summer, with 13.28 miles per hour. Data recovery for the entire period was 69 percent.

The Reserve site was located 10 miles southeast of Reserve at 48 30 58 N and 104 18 23 W (Site No. 115 on Map II-1). Site elevation was 2,234 feet. The area is one of high grass and grains. The anemometer was installed on a radio tower leg at 30 feet. There were no obstructions in the area, but the tower itself could have affected the readings. Data was collected from January 29, 1982 to June 30, 1985 by Sheridan Electric Cooperative. Average wind speed was 11.13 miles per hour. Highest average wind speed was in the spring, at 12.17 miles per hour, and lowest was in the fall at 10.50 miles per hour. Data recovery for the entire period was 72 percent.

The Fairfield site was located 3 miles west of Fairfield, at 47 36 31 N and 112 02 43 W (Site No. 126 on Map II-1). Elevation at the site was 4,200 feet. The site was the highest ground within a ten-mile radius, in a grassland area near the Rocky Mountain Front. Anemometer height was reported at 30 feet, but DNRC has learned that the actual height probably was lower. Data were collected between December 30, 1981 and January 3, 1985 by Sun River Electric Cooperative. Average wind speed was 11.45 miles per hour. Highest average wind speed was in the winter, at 13.04 miles per hour, while the lowest was in the summer at 9.29 miles per hour. Data recovery for the entire period was 91 percent.

The Pendroy site was located 8 miles northwest of Pendroy, at 48 07 45 N and 112 26 20 W (Site No. 127 on Map II-1). Elevation at the site was 4,550 feet. The area is rolling grasslands near the Rocky Mountain Front. Data was collected from March 17, 1983 to December 19, 1984 by Sun River Electric Cooperative. Anemometer height was 31 feet. Average wind speed was 9.93 miles per hour. Highest average wind speed was 12.52 miles per hour in the winter and lowest was 9.02 miles per hour in the summer. Data recovery over the period was 86 percent.

Table C - 4A

Western Area Power Administration

EKALAKA

Carter County

ELEVATION:3460. FT ACTUAL

ANEMOMETER HT:36.1 FT ACTUAL

MONTHLY AND DIURNAL AVERAGE WIND SPEEDS (MPH)

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CUMULATIVE
MID-3AM	WIND SPEED (MPH)	9.45	9.00	10.93	10.83	9.66	8.91	9.03	9.63	8.64	7.67	7.76	9.76	9.41
	HOURS OF USABLE DATA	279.	250.	264.	267.	231.	219.	236.	230.	190.	141.	179.	229.	2714.
3AM-6AM	WIND SPEED (MPH)	9.54	9.30	9.91	9.74	8.97	9.17	8.05	8.89	8.61	7.72	8.86	9.69	9.12
	HOURS OF USABLE DATA	279.	249.	263.	266.	233.	214.	237.	229.	188.	140.	180.	230.	2707.
6AM-9AM	WIND SPEED (MPH)	9.26	9.10	9.77	11.39	10.99	10.85	10.00	9.73	9.11	8.60	9.33	9.55	9.87
	HOURS OF USABLE DATA	278.	250.	261.	268.	233.	218.	237.	231.	191.	141.	180.	228.	2713.
9AM-NOON	WIND SPEED (MPH)	9.96	10.03	11.22	12.97	12.05	11.28	10.37	10.80	11.04	10.81	10.08	9.49	10.87
	HOURS OF USABLE DATA	275.	251.	266.	271.	234.	219.	236.	232.	189.	142.	180.	229.	2724.
NOON-3PM	WIND SPEED (MPH)	10.56	10.61	11.75	13.38	12.54	11.21	9.84	10.75	11.57	11.87	10.27	9.31	11.15
	HOURS OF USABLE DATA	279.	252.	266.	270.	232.	221.	234.	234.	189.	144.	180.	234.	2735.
3PM-6PM	WIND SPEED (MPH)	9.62	9.24	10.64	12.36	11.78	10.68	9.77	10.71	10.51	10.14	8.25	8.86	10.26
	HOURS OF USABLE DATA	278.	252.	267.	270.	231.	222.	234.	234.	189.	144.	181.	234.	2736.
6PM-9PM	WIND SPEED (MPH)	9.51	8.64	9.66	9.56	9.04	8.43	8.92	9.09	7.47	8.54	7.84	9.44	8.93
	HOURS OF USABLE DATA	276.	250.	266.	269.	230.	220.	233.	231.	184.	142.	176.	234.	2711.
9PM-MID	WIND SPEED (MPH)	9.51	9.00	10.43	10.17	9.64	8.76	9.80	9.70	9.35	8.75	7.87	9.63	9.47
	HOURS OF USABLE DATA	278.	251.	266.	269.	231.	219.	233.	232.	183.	143.	174.	234.	2710.
FULL MONTH	WIND SPEED (MPH)	9.68	9.37	10.54	11.12	10.09	9.82	9.51	9.92	9.55	9.16	8.64	9.31	
	HOURS OF USABLE DATA	2220.	2004.	2120.	2521.	2711.	2636.	2019.	1852.	1502.	1304.	2146.	2215.	

SEASONAL AND ANNUAL VELOCITY DISTRIBUTION PARAMETERS

	WINTER (DJF)	SPRING (MAM)	SUMMER (JJA)	FALL (SON)	ANNUAL	CUMULATIVE
WEIBULL,K	1.84	1.73	1.78	1.68	1.75	1.75
WEIBULL,C	10.64	11.86	10.96	10.14	10.90	10.97
AVERAGE WIND SPEED (MPH)	9.45	10.57	9.75	9.05	9.71	9.78
STANDARD DEVIATION	5.33	6.29	5.68	5.53	5.72	5.78
FLUX (WATT/M**2)	84.7	127.2	96.9	82.7	97.1	99.6
HOURS OF USABLE DATA	6439.	7352.	6506.	5032.		25328.

Table C - 4B

Western Area Power Administration

CIRCLE

McCone County

ELEVATION:3467. FT ACTUAL

ANEMOMETER HT:30.0 FT ACTUAL

MONTHLY AND DIURNAL AVERAGE WIND SPEEDS (MPH)

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CUMULATIVE
MID-3AM	WIND SPEED (MPH)	13.31	12.86	14.71	14.66	15.02	16.15	14.44	16.96	14.62	14.90	13.76	15.43	14.68
	HOURS OF USABLE DATA	247.	144.	218.	284.	153.	132.	291.	231.	90.	114.	266.	156.	2326.
3AM-6AM	WIND SPEED (MPH)	12.71	13.17	14.91	14.16	13.49	16.39	13.71	16.49	13.94	14.16	13.02	15.05	14.20
	HOURS OF USABLE DATA	244.	144.	218.	283.	151.	132.	291.	231.	90.	114.	267.	156.	2320.
6AM-9AM	WIND SPEED (MPH)	12.90	12.78	15.11	14.59	13.50	14.90	13.76	15.35	14.31	12.79	12.25	14.05	13.87
	HOURS OF USABLE DATA	230.	144.	216.	282.	151.	133.	291.	231.	90.	114.	267.	157.	2306.
9AM-NOON	WIND SPEED (MPH)	13.14	13.48	16.74	16.20	14.68	15.56	14.35	15.27	16.18	14.26	13.15	13.60	14.69
	HOURS OF USABLE DATA	229.	145.	216.	284.	153.	136.	289.	233.	91.	116.	266.	161.	2318.
NOON-3PM	WIND SPEED (MPH)	15.14	16.20	17.03	16.54	15.46	16.03	13.38	14.73	16.87	16.57	14.30	13.88	15.33
	HOURS OF USABLE DATA	235.	140.	221.	282.	151.	138.	289.	228.	93.	117.	266.	159.	2319.
3PM-6PM	WIND SPEED (MPH)	14.85	15.52	16.36	15.52	15.26	15.73	12.02	14.86	16.12	15.32	13.72	14.39	14.76
	HOURS OF USABLE DATA	244.	141.	227.	279.	150.	138.	291.	225.	93.	118.	267.	160.	2333.
6PM-9PM	WIND SPEED (MPH)	14.81	14.43	16.15	13.85	14.53	16.05	11.73	15.33	13.58	13.07	13.83	15.29	14.31
	HOURS OF USABLE DATA	245.	141.	229.	279.	150.	138.	291.	225.	93.	117.	264.	159.	2332.
9PM-MID	WIND SPEED (MPH)	14.32	13.09	15.90	14.60	15.45	15.81	13.76	16.59	13.72	14.15	14.20	15.70	14.79
	HOURS OF USABLE DATA	245.	141.	231.	279.	150.	138.	290.	225.	93.	117.	261.	159.	2328.
FULL MONTH	WIND SPEED (MPH)	13.91	13.92	15.37	15.91	15.15	14.28	14.09	15.39	14.34	14.41	13.53	14.67	
	HOURS OF USABLE DATA	1919.	1919.	2401.	2599.	2439.	2100.	2963.	2214.	1943.	927.	2124.	1267.	

SEASONAL AND ANNUAL VELOCITY DISTRIBUTION PARAMETERS

	WINTER (DJF)	SPRING (MAM)	SUMMER (JJA)	FALL (SON)	ANNUAL	CUMULATIVE
WEIBULL,K	1.94	2.04	2.25	2.15	2.08	2.08
WEIBULL,C	15.90	17.48	16.42	15.81	16.41	16.51
AVERAGE WIND SPEED (MPH)	14.10	15.49	14.54	14.01	14.53	14.63
STANDARD DEVIATION	7.59	7.95	6.85	6.86	7.33	7.38
FLUX (WATT/M**2)	266.6	333.9	253.6	235.5	270.7	275.9
HOURS OF USABLE DATA	5105.	7439.	7277.	4993.		24814.

Table C - 4C

Western Area Power Administration

MT. ANTIONE

Phillips County

ELEVATION:5765. FT ACTUAL

ANEMOMETER HT:29.9 FT ACTUAL

MONTHLY AND DIURNAL AVERAGE WIND SPEEDS (MPH)

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CUMULATIVE
MID-3AM	WIND SPEED (MPH)	0.00	0.00	12.99	17.69	14.97	14.96	12.63	11.57	14.95	0.00	13.21	16.31	14.21
	HOURS OF USABLE DATA	0.	0.	46.	93.	102.	135.	189.	93.	51.	0.	45.	51.	804.
3AM-6AM	WIND SPEED (MPH)	0.00	0.00	12.29	17.47	13.68	13.89	12.09	12.31	15.32	0.00	13.49	15.91	13.79
	HOURS OF USABLE DATA	0.	0.	48.	97.	102.	135.	189.	93.	51.	0.	45.	51.	810.
6AM-9AM	WIND SPEED (MPH)	0.00	0.00	11.89	14.85	11.72	13.32	12.09	12.39	15.03	0.00	14.83	16.32	13.20
	HOURS OF USABLE DATA	0.	0.	48.	97.	102.	136.	189.	93.	51.	0.	45.	51.	812.
9AM-NOON	WIND SPEED (MPH)	0.00	0.00	10.36	14.40	12.12	13.91	12.38	13.21	14.86	0.00	13.54	16.78	13.31
	HOURS OF USABLE DATA	0.	0.	48.	95.	105.	135.	189.	92.	51.	0.	43.	51.	809.
NOON-3PM	WIND SPEED (MPH)	0.00	0.00	10.63	15.31	12.72	14.14	12.57	14.99	14.89	0.00	11.04	14.37	13.50
	HOURS OF USABLE DATA	0.	0.	51.	96.	104.	134.	188.	90.	51.	0.	44.	51.	810.
3PM-6PM	WIND SPEED (MPH)	0.00	0.00	10.66	15.14	13.25	14.94	12.97	15.92	15.86	0.00	9.72	14.80	13.88
	HOURS OF USABLE DATA	0.	0.	51.	94.	102.	135.	189.	90.	51.	0.	47.	50.	809.
6PM-9PM	WIND SPEED (MPH)	0.00	0.00	11.42	14.96	13.18	14.48	12.69	13.64	18.64	0.00	10.94	16.30	13.83
	HOURS OF USABLE DATA	0.	0.	51.	92.	102.	135.	189.	90.	51.	0.	46.	48.	804.
9PM-MID	WIND SPEED (MPH)	0.00	0.00	12.98	16.83	14.71	14.56	12.58	11.93	16.36	0.00	12.99	17.67	14.18
	HOURS OF USABLE DATA	0.	0.	49.	90.	102.	137.	189.	91.	50.	0.	47.	48.	802.
FULL MONTH	WIND SPEED (MPH)	0.00	15.64	12.01	15.83	13.71	14.14	12.50	13.23	15.74	13.40	15.05	15.05	
	HOURS OF USABLE DATA	0.	814.	1071.	752.	1046.	1410.	1512.	732.	407.	157.	698.	401.	

SEASONAL AND ANNUAL VELOCITY DISTRIBUTION PARAMETERS

	WINTER (DJF)	SPRING (MAM)	SUMMER (JJA)	FALL (SON)	ANNUAL	CUMULATIVE
WEIBULL,K	1.54	1.72	2.05	1.75	0.00	1.77
WEIBULL,C	17.52	15.29	14.98	16.91	0.00	15.70
AVERAGE WIND SPEED (MPH)	15.77	13.63	13.28	15.07	0.00	13.98
STANDARD DEVIATION	10.48	8.16	6.80	8.91	0.00	8.17
FLUX (WATT/M**2)	454.8	252.1	192.5	335.0	0.0	263.4
HOURS OF USABLE DATA	1215.	2869.	3653.	1262.		8999.

Table C - 4D

Western Area Power Administration

RESERVE

Sheridan County

ELEVATION:2234. FT ACTUAL

ANEMOMETER HT:29.9 FT ACTUAL

MONTHLY AND DIURNAL AVERAGE WIND SPEEDS (MPH)

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CUMULATIVE
MID-3AM	WIND SPEED (MPH)	10.78	9.86	11.53	10.58	10.98	9.11	9.62	9.62	10.79	8.34	0.00	11.25	10.23
	HOURS OF USABLE DATA	138.	212.	171.	138.	138.	180.	186.	234.	214.	45.	0.	45.	1701.
3AM-6AM	WIND SPEED (MPH)	11.25	9.89	11.05	10.03	10.57	9.12	9.16	9.33	10.99	8.89	0.00	10.46	10.07
	HOURS OF USABLE DATA	137.	210.	168.	138.	136.	180.	186.	234.	216.	45.	0.	45.	1696.
6AM-9AM	WIND SPEED (MPH)	10.38	10.01	11.55	11.48	12.22	11.04	10.30	9.67	11.62	9.34	0.00	10.59	10.79
	HOURS OF USABLE DATA	136.	210.	170.	138.	140.	180.	186.	235.	215.	43.	0.	45.	1697.
9AM-NOON	WIND SPEED (MPH)	10.65	10.84	13.17	14.19	12.95	12.97	12.78	10.68	13.07	13.30	0.00	11.04	12.26
	HOURS OF USABLE DATA	141.	210.	168.	135.	141.	180.	186.	237.	213.	42.	0.	45.	1697.
NOON-3PM	WIND SPEED (MPH)	11.20	11.72	14.31	14.53	13.95	13.24	13.53	11.80	13.65	13.53	0.00	10.72	12.97
	HOURS OF USABLE DATA	141.	213.	171.	135.	141.	180.	186.	237.	213.	42.	0.	45.	1703.
3PM-6PM	WIND SPEED (MPH)	11.14	11.47	13.97	12.87	13.53	12.73	13.35	12.20	13.14	11.50	0.00	11.37	12.62
	HOURS OF USABLE DATA	139.	212.	171.	135.	141.	180.	186.	237.	211.	42.	0.	47.	1702.
6PM-9PM	WIND SPEED (MPH)	11.64	10.98	12.91	9.90	11.74	10.42	10.72	10.96	10.91	9.46	0.00	10.13	11.04
	HOURS OF USABLE DATA	141.	210.	171.	135.	141.	180.	184.	236.	210.	42.	0.	48.	1698.
9PM-MID	WIND SPEED (MPH)	11.18	9.94	12.80	10.25	11.19	9.26	10.26	10.54	10.68	8.35	0.00	10.73	10.58
	HOURS OF USABLE DATA	142.	210.	171.	135.	141.	180.	182.	237.	210.	42.	0.	48.	1697.
FULL MONTH	WIND SPEED (MPH)	11.03	10.46	12.03	12.11	12.34	10.95	11.22	10.61	11.82	10.15	9.37	10.14	
	HOURS OF USABLE DATA	1115.	2005.	2124.	2174.	2442.	1782.	1482.	1887.	1975.	1876.	1735.	891.	

SEASONAL AND ANNUAL VELOCITY DISTRIBUTION PARAMETERS

	WINTER (DJF)	SPRING (MAM)	SUMMER (JJA)	FALL (SON)	ANNUAL	CUMULATIVE
WEIBULL,K	1.86	1.85	1.86	1.75	1.83	1.81
WEIBULL,C	11.87	13.70	12.27	11.78	12.41	12.51
AVERAGE WIND SPEED (MPH)	10.55	12.17	10.90	10.50	11.03	11.13
STANDARD DEVIATION	5.89	6.83	6.09	6.20	6.26	6.37
FLUX (WATT/M**2)	121.3	167.5	134.1	128.6	141.6	146.8
HOURS OF USABLE DATA	4011.	6739.	5151.	5585.		21486.

Table C - 4E

Western Area Power Administration

FAIRFIELD

Teton County

ELEVATION:4200. FT ACTUAL

ANEMOMETER HT:29.9 FT ACTUAL

MONTHLY AND DIURNAL AVERAGE WIND SPEEDS (MPH)

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CUMULATIVE
MID-3AM	WIND SPEED (MPH)	13.31	11.78	10.55	12.52	10.12	8.47	7.64	7.32	9.50	10.24	11.44	12.03	10.66
	HOURS OF USABLE DATA	285.	250.	194.	177.	186.	264.	126.	174.	178.	186.	250.	279.	2549.
3AM-6AM	WIND SPEED (MPH)	13.67	12.23	10.59	13.08	10.04	9.26	7.19	8.35	10.45	10.23	11.37	12.11	10.98
	HOURS OF USABLE DATA	288.	252.	195.	177.	186.	264.	126.	174.	180.	186.	249.	278.	2554.
6AM-9AM	WIND SPEED (MPH)	14.60	12.02	10.72	13.51	11.42	9.55	8.56	8.62	10.67	9.97	11.71	12.32	11.37
	HOURS OF USABLE DATA	288.	252.	193.	177.	186.	264.	125.	174.	180.	187.	249.	281.	2555.
9AM-NOON	WIND SPEED (MPH)	14.56	14.40	12.86	14.51	12.78	9.72	10.28	10.22	12.27	12.30	14.48	13.13	12.79
	HOURS OF USABLE DATA	284.	253.	193.	175.	186.	266.	120.	174.	180.	186.	253.	292.	2562.
NOON-3PM	WIND SPEED (MPH)	15.09	15.42	12.70	13.87	13.79	9.53	11.45	10.98	12.76	13.10	15.28	13.54	13.27
	HOURS OF USABLE DATA	285.	251.	191.	177.	186.	267.	120.	176.	181.	184.	254.	284.	2557.
3PM-6PM	WIND SPEED (MPH)	13.50	14.04	11.26	14.48	14.73	9.86	11.34	11.43	12.40	11.31	12.70	12.58	12.50
	HOURS OF USABLE DATA	285.	251.	192.	177.	186.	267.	120.	177.	180.	186.	258.	284.	2562.
6PM-9PM	WIND SPEED (MPH)	12.59	11.83	10.42	12.17	12.91	9.09	9.71	9.72	9.94	10.11	11.25	12.04	11.09
	HOURS OF USABLE DATA	285.	252.	191.	177.	186.	267.	120.	177.	179.	186.	257.	284.	2560.
9PM-MID	WIND SPEED (MPH)	12.65	11.03	10.83	11.69	10.49	8.46	9.13	8.32	9.63	10.16	11.23	12.17	10.64
	HOURS OF USABLE DATA	283.	252.	191.	177.	186.	267.	120.	177.	179.	186.	255.	281.	2553.
FULL MONTH	WIND SPEED (MPH)	13.75	12.84	10.89	12.06	11.60	9.24	9.38	9.30	11.04	10.93	12.44	12.49	
	HOURS OF USABLE DATA	2283.	2012.	2234.	2148.	2209.	2126.	978.	2111.	2126.	1487.	2023.	2252.	

SEASONAL AND ANNUAL VELOCITY DISTRIBUTION PARAMETERS

	WINTER (DJF)	SPRING (MAM)	SUMMER (JJA)	FALL (SON)	ANNUAL	CUMULATIVE
WEIBULL,K	1.79	1.67	1.76	1.85	1.75	1.72
WEIBULL,C	14.65	12.88	10.43	12.96	12.73	12.84
AVERAGE WIND SPEED (MPH)	13.04	11.51	9.29	11.51	11.34	11.45
STANDARD DEVIATION	7.52	7.09	5.46	6.45	6.67	6.87
FLUX (WATT/M**2)	222.7	167.6	82.7	147.7	150.5	158.9
HOURS OF USABLE DATA	6546.	6590.	5214.	5636.		23986.

Table C - 4F

Western Area Power Administration

PENDROY

Teton County

ELEVATION:4550. FT ACTUAL

ANEMOMETER HT:31.2 FT ACTUAL

MONTHLY AND DIURNAL AVERAGE WIND SPEEDS (MPH)

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CUMULATIVE
MID-3AM	WIND SPEED (MPH)	16.20	11.46	8.64	8.33	8.67	8.36	7.90	8.04	8.52	7.57	7.89	10.18	9.07
	HOURS OF USABLE DATA	93.	84.	135.	151.	93.	117.	135.	54.	150.	129.	156.	90.	1386.
3AM-6AM	WIND SPEED (MPH)	15.89	11.77	7.48	7.90	7.95	8.49	6.77	7.91	8.96	7.60	8.01	9.88	8.80
	HOURS OF USABLE DATA	93.	84.	135.	146.	93.	117.	135.	54.	150.	129.	156.	90.	1301.
6AM-9AM	WIND SPEED (MPH)	15.11	10.11	7.93	8.74	10.84	8.98	7.95	7.66	9.07	6.93	8.51	10.24	9.16
	HOURS OF USABLE DATA	93.	84.	133.	149.	93.	118.	135.	55.	150.	129.	156.	90.	1384.
9AM-NOON	WIND SPEED (MPH)	15.04	10.57	10.53	9.54	13.66	9.63	8.43	10.49	11.49	9.02	10.09	10.91	10.51
	HOURS OF USABLE DATA	93.	84.	133.	151.	93.	121.	131.	58.	147.	130.	154.	87.	1379.
NOON-3PM	WIND SPEED (MPH)	15.49	12.06	12.20	10.29	14.95	9.65	10.52	11.56	13.30	10.32	11.01	11.55	11.75
	HOURS OF USABLE DATA	93.	84.	133.	150.	93.	120.	129.	57.	147.	132.	153.	90.	1381.
3PM-6PM	WIND SPEED (MPH)	14.12	12.37	12.37	11.05	16.29	10.61	11.50	12.13	13.32	10.01	9.46	11.61	11.87
	HOURS OF USABLE DATA	93.	84.	135.	150.	93.	120.	129.	59.	147.	132.	153.	89.	1384.
6PM-9PM	WIND SPEED (MPH)	15.65	10.54	9.27	9.34	11.87	9.72	9.35	10.68	9.41	8.88	7.63	10.44	9.93
	HOURS OF USABLE DATA	93.	84.	137.	150.	93.	120.	129.	60.	147.	132.	153.	88.	1386.
9PM-MID	WIND SPEED (MPH)	15.86	10.25	8.62	8.78	9.11	8.74	8.33	9.03	8.92	7.88	8.29	11.49	9.36
	HOURS OF USABLE DATA	93.	84.	138.	150.	93.	120.	129.	60.	147.	132.	153.	90.	1389.
FULL MONTH	WIND SPEED (MPH)	15.42	11.14	9.62	9.42	10.76	9.55	8.58	8.82	10.36	8.53	8.85	10.80	
	HOURS OF USABLE DATA	744.	672.	1079.	1427.	1408.	1438.	1257.	1040.	1185.	1044.	1233.	713.	

SEASONAL AND ANNUAL VELOCITY DISTRIBUTION PARAMETERS

	WINTER (DJF)	SPRING (MAM)	SUMMER (JJA)	FALL (SON)	ANNUAL	CUMULATIVE
WEIBULL,K	1.34	1.49	1.63	1.38	1.41	1.42
WEIBULL,C	13.63	11.03	10.07	10.15	11.20	10.91
AVERAGE WIND SPEED (MPH)	12.52	9.96	9.02	9.27	10.19	9.93
STANDARD DEVIATION	9.46	6.78	5.69	6.79	7.31	7.11
FLUX (WATT/M**2)	296.5	124.7	82.4	113.8	146.0	134.5
HOURS OF USABLE DATA	2129.	3914.	3734.	3461.		13238.

Electric Power Research Institute

The Electric Power Research Institute (EPRI) is conducting studies to acquire representative visibility and air quality data in the western United States. As part of this study, wind measurements have been collected at a site approximately 2 miles northwest of Harlowton. Monitoring was conducted from June 1981 to October 1982 with a Climatronics F460 wind measurement system. Anemometer height was 10 meters.

The data, which consist of wind speed and wind direction values recorded every five out of eight days during daylight hours, are not available to the public at this time.

Bonneville Power Administration

From May 1-3, 1981, Oregon State University, under contract to Bonneville Power Administration, conducted aerial wind prospecting surveys over western Montana as part of the Wind Regional Energy Assessment Program. Aerial surveys are a rapid means of assessing wind power potential over a large area. In such surveys, indicators of high wind speeds, such as wind-deformed trees, are observed from the air. In addition, the roughness of the terrain, tree cover, ease of access, and location of transmission lines can be determined.

The OSU wind prospecting survey covered western Montana from south of Dillon to the Canadian border, and from the eastern front of the Rocky Mountains to the Idaho state line. Areas with an apparent high wind potential were found on exposed ridge crests and summits in all of the areas surveyed. Nearly all of these locations, however, are remote and inaccessible during the winter.

Based on the survey results, OSU recommended that wind monitors be installed at these locations:

1) Site 134, 24 miles south-southwest of Dillon;
2) Site 138, 24 miles southwest of Dillon;
3) Site 151, 10 miles east-northeast of Ennis;
4) Site 152, 4 miles southeast of Norris;
5) Site 159, 10 miles northeast of Whitehall;
6) Site 173, 6 miles north-northwest of Anaconda;
7) Site 178, 5 miles west-southwest of Philipsburg;
8) Site 186, 10 miles west of Drummond;
9) Site 188, 4 miles west of Drummond;
10) Site 200, 16 miles west of Helena;

Table C-5
Oregon State University
Wind Prospecting Fly Over

Site Area	No.	Estimated Mean Annual Wind Speed (mph)	Existing Communications Facilities
Dillon & Butte	134	15-19	Yes
	138	13-17	Yes
	151	14-17	No
	152	13-16	Yes
	159	15-18	Yes
	173	12-15	No
	178	12-15	No
Missoula & Helena	186	14-17	No
	188	14-17	Yes
	200	14-17	Yes
	217	16-19	No
Browning	252	17-21	No
	258	17-21	No
	261	15-18	No
	274	14-17	Yes

11) Site 217, 18 miles north-northwest of Helena;
12) Site 252, 4 miles northeast of Saint Mary;
13) Site 258, 16 miles south-southwest of Browning;
14) Site 261, 18 miles west of Dupuyer;
15) Site 274, 10 miles southwest of Browning.

In September 1981, wind monitors were installed at sites 188, 258 (Rainbow Field), 261 (Swift Dam), and at Heart Butte (site 260) and at Blackfoot, about 4 miles northwest of Browning. In November 1981, the anemometer at site 188 was relocated to site 200 (MacDonald Pass). Blackfoot, Swift Dam, and Heart Butte had wind-run anemometers. A stripchart recorder was installed at Rainbow Field and a CR-21 data logger was installed at MacDonald Pass. The Rainbow Field equipment was removed in November 1982. That same month, a CR-21 data logger was installed at Heart Butte, and a wind-run anemometer was installed at Duck Lake, approximately 5 miles east of Babb. Wind-run anemometers were installed at Whitehall in September 1983 and at Sieben 2 in October 1983. The Whitehall site is on a microwave tower just northeast of the town, while the Sieben 2 site is on a rocky point 27 miles northwest of Helena. The Blackfoot site was converted to an hourly data logger system in July 1984. Data from wind-run anemometers at these sites are presented in Table C-6. Data recovery in many instances was poor, due to the extremely harsh weather at the sites. All the wind-run anemometers were closed down by July 1984.

U.S. Forest Service

The U.S. Forest Service maintains a collection of historical weather data from more than 800 stations in the northwestern United States. The data were recorded from observations that took place once per day (usually in the early afternoon) during the fire season (generally May through September).

The data set includes data on wind direction and speed, temperature, relative humidity, and other parameters necessary for estimating fire hazards. Each January, data from the previous year are incorporated into each station's data set and stored on computer tapes.

While most of the stations have only one observation per day, some have three observations per day. Some of the station data histories date back to the 1920s.

These data have been analyzed by Battelle Pacific Northwest Laboratories. Those stations in Montana for which at least 70 percent of the wind speed observations were equal to or greater than 3.5 meters per second (7.8 miles per hour) are listed in Tables C-7 and C-8.

Table C-6
Bonneville Power Administration Wind-Run Monitoring Sites
Average Velocity Oct 1981 - Jul 1984 (mph)

Site		Rainbow Field	Blackfoot	Swift Dam	Heart Butte	Duck Lake	MacDonald Pass	Sieben 2	Whitehall
Anemometer Height (ft)		(30)	(30)	(30)	(35)	(30)	(30)	(57)	(30)
1981	Oct	15.7	14.5	14.4	15.5				
	Nov	19.9	16.8	17.1	18.2		22.5		
	Dec	17.1	18.0	17.7	16.5		40.4		
1982	Jan	18.6	19.3	16.4	19.1		M		
	Feb	21.0	16.8	16.9	18.9		M		
	Mar	M	12.6	M	M		M		
	Apr	M	18.4	M	17.3		M		
	May	M	11.9	12.9	16.7		M		
	Jun	M	11.7	10.8	M		M		
	Jul	M	12.5	11.4	14.7		M		
	Aug	M	13.6	7.4	12.6		M		
	Sep	M	13.2	12.9	11.9		M		
	Oct	M	14.1	M	18.1		M		
	Nov		18.2	M		20.4	21.1		
	Dec		19.3	M		19.0	22.4		
1983	Jan		19.3	M		19.0	23.8		
	Feb		M	10.5		16.9			
	Mar		9.6	6.1		10.4			
	Apr		12.5	12.5		13.7			
	May		13.7	8.5		14.6			
	Jun		14.7	12.1		15.6			
	Jul		13.5	10.0		13.0			
	Aug		IM	IM		IM			
	Sep		IM	IM		10.6			11.9
	Oct		IM	13.1		12.7		12.5	12.4
	Nov		16.8	14.7		15.7		14.0	15.3
	Dec		14.8	20.2		15.7		14.5	14.2
1984	Jan		18.1	20.2		20.4		14.2	20.1
	Feb		18.1	12.0		20.4		14.2	19.6
	Mar		18.1	12.7		20.4		15.8	13.6
	Apr		13.6	11.7		14.4		12.0	14.7
	May		16.6	IM		M		15.5	14.7
	Jun		13.5	8.4				15.5	12.2
	Jul		13.5					7.6	11.6
Avg of monthly averages		18.5*	15.2*	12.9*	16.3*	16.1*	22.5#	13.6*	14.6*

M - Missing data
IM - Instrument malfunction
* - Data recovery < 80%
\# - Average excludes December, 1981
N.B. Blackfoot and Heart Butte were converted to hourly logging systems at the end of data-gathering periods shown in the table.

Table C-7
U.S. Forest Service
Fire Weather Data Sites

Station Number	Station Location	Lat. (Deg)	Long. (Deg)	Elev. (m)	Total Obser.	Period of Record
240102	Kootenai National Forest	48.51	115.55	1,992	147	1967-72
240805	Phillips County	48.48	107.50	900	447	1970-72
241208	Kaniksa National Forest	48.06	115.55	1,879	616	1961-72
241801	Lewis & Clark National Forest	47.48	112.51	2,465	594	1962-73
241905	Helena National Forest	47.06	112.11	2,316	691	1961-73
242101	Lewis & Clark National Forest	46.42	110.16	2,527	261	1961-65
242201	Lewis & Clark National Forest	47.04	109.28	1,263	297	1961-65
243001	Deer Lodge National Forest	46.11	113.37	2,621	244	1960-67
243102	Flathead National Forest	47.24	113.30	2,516	457	1961-72
243402	Lewis & Clark National Forest	46.54	110.42	2,528	1,000	1962-77
244101	Miles City	46.23	105.50	801	1,407	1966-77
244604	Gallatin National Forest	44.45	111.13	2,157	263	1965-68
244605	Helena National Forest	45.80	111.16	2,814	114	1965-68
244701	Gallatin National Forest	45.60	110.14	3,008	242	1965-68

Table C-8

U.S. Forest Service
Fire Weather Data Summaries

Station Number	Station Location	Anemometer Height (m)	Mean Wind Speed (m/s)	Mean Total Wind Power (watts/m²)
240102	Kootenai National Forest	7	5.14	194
240805	Phillips County	6	5.00	196
241208	Kaniksa National Forest	7	5.55	262
241801	Lewis & Clark National Forest	8	5.96	237
241905	Helena National Forest	10	7.41	436
242101	Lewis & Clark National Forest	Not reported	6.14	314
242201	Lewis & Clark National Forest	Not reported	5.60	214
243001	Deer Lodge National Forest	Not reported	4.62	101
243103	Flathead National Forest	7	6.60	508
243402	Lewis & Clark National Forest	15	5.04	140
244101	Miles City, MT	10	5.69	227
244605	Gallatin National Forest	20	7.74	529
244605	Helena National Forest	Not reported	6.37	270
244703	Gallatin National Forest	5	6.74	218

Appendix D

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